Unit 44: Land-based Engineering Operations – Use Calculations

Unit code: A/600/3430

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

The aim of this unit is to provide the learner with the knowledge and skills required to use calculations to support land-based engineering principles. This unit aims to introduce learners to the use of calculations in land-based engineering 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 gain a sound understanding of many of the calculations used in land-based engineering operations. The skills acquired in this unit will readily transfer to other level 2 units and will also be a solid foundation for level 3 mathematics based units. This unit will enable learners to carry out tests in the workshop environment and check the accuracy of those tests using calculation methods.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use calculations to support engineering principles

2 Know how to use calculations to support engineering principles.

Unit content

1 Be able to use calculations to support engineering principles

Transmissions: calculations to include reduction ratios as found in final drives, starter motors etc, Simple and compound ratios eg gearboxes, gear trains; calculation of speed from ratios and input and output speed; torque capacity of clutches including spring force, torque capacity, friction

Engines: measurements to include power, noise, fuel consumption, oil consumption; calculations including torque, torque reserve, compression ratio with regard to Boyle's Law

Hydraulics: calculations eg flow, pressure, load, lifting force, etc

Pneumatic: calculations eg flow, pressure etc

Machine performance: calculations eg velocity, acceleration, deceleration based on Newton's laws of Motion, calibration calculations to include application rate

Electrical performance: calculations eg current draw, resistance and power with regard to Ohm's Law; battery measurements eg specific gravity, electrolyte density, volts eg open circuit voltage, voltage drop under load

2 Know how to use calculations to support engineering principles

Calculations: units of measurement; conversion tables; mathematical formulae; measurements; how to use conversion factors for calculations eg conversion of non-SI units into SI units; use of conversion tables eg power ratings (BHP or KW); what they represent including ECE, DIN, SAE

General formulas: area, volume and circular calculations; the relationship between speed and torque; how to carry out measurement operations for land-based engineering operations

Underpinning principles: where relevant (Ohm's Law, Newton's Law of Motion, Boyle's Law, Pascal's Law)

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 ratios and units of measurement to express values	**M1** explain how the results of calculation and measurement tasks may be checked to ensure accuracy	**D1** discuss how given measurements and calculations are used in land-based engineering operations.
P2 use conversion factors to convert measurement values from one unit of measurement to another [IE, CT, RL]		
P3 calculate and measure: ◊ areas ◊ weights ◊ volumes ◊ angles ◊ flow rates and speeds ◊ scaling		
P4 use physical and theoretical methods to establish measurements where relevant		
P5 verify by calculation the calibration of machinery and equipment [TW, SM, EP]		
P6 identify units of measurement used to express values	**M2** explain why calculated data may differ from measured results.	
P7 state how to use conversion tables		
P8 define the mathematical formulas for: ◊ area ◊ volume ◊ circumference		

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:**
P9 state the relationship between speed and torque		
P10 describe how to calculate power, torque, force, consumption and application rates		
P11 describe the methods and equipment required to carry out a measuring task and the factors that can distort measurements		
P12 describe how to measure: ◊ speed ◊ velocity ◊ acceleration ◊ deceleration ◊ coefficient of friction.		

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 practical assessments, written assessment, visits to suitable collections and will link to industrial experience placements.

This unit should be delivered in a practical environment where applicable. Each calculation should derive from a hands on approach. Each aspect should be physically measured/investigated and then calculated during the same session. Tutors should avoid situations where practical takes place but the corresponding calculation theory is delivered some time in the future, this can lead to a disjointed learning process.

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, with examples of how calculations and measurements are important in land-based engineering.
Assignment 1: Measurements and Calculations (P1, P2, P3, P4, P5, P6, M1) Tutor introduces assignment.
Units of measurements: SI units and non-SI units.
Units of measurement: conversion factors.
Practical mathematical exercises to practise using conversion factors and units of measurement.
Theory session with practice: measuring and calculating areas, weights, volumes, angles, flow rates and speeds, scaling.
Measurements and calculations: practical activities designed to integrate the calculation and measurement of areas, weights, volumes, angles, flow rates, velocity and scaling.
Calibration practical and calculations.
Assignment 2: Using Calculations in Land-based Engineering (P7, P8, P9, P10, P11, P12, M2, D1) Tutor introduces assignment.
Theory and practice: calculating power, torque, force, consumption, application rates.
Practicals designed to integrate formulae relating to engines, power/torque, machine performance.
Practical session: using equipment and methods for measuring tasks.
Classroom activities: differences between measurement and calculations in land-based engineering.
Theory and practice: how to measure speed, velocity, acceleration, deceleration, coefficient of friction.
Assessment completion.
Unit review.

Assessment

For those assessment criteria requiring calculations and/or measurement (P1, P2, P3, P4, P5) evidence may be a completed workbook, series of completed exercises or an in-class test. Learners should demonstrate their understanding of the calculations by showing their workings as well as the final answer. It will be beneficial if exercises/tasks are linked to the land-based engineering sector so learners recognise the vocational relevance and significance of the mathematical tasks they are carrying out.

For P1, learners need to demonstrate that they can choose the correct unit of measurement for particular values. Learners need to be aware that all values will need a correct unit except in the case of ratios.

For P2, learners must convert values from one unit into another and back again. Learners and tutors should always strive to use the correct SI unit in calculations. However, it may be of benefit to convert from kilopascal (KPa) to a unit that learners are more familiar with (Bar, psi, atm) for reasons of clarification of explanation only for example 101.3529 Kpa = 14.7psi

For P3, learners must use calculations/measurement as listed in the assessment and grading criteria grid. This could be linked to a practical investigation, and it would be beneficial for the calculations to be set in a land-based engineering context.

For P4, learners need use measurement equipment to establish correct measurements. Again, this should be practically based and can link to other units as necessary. For example, measurement of engine bore and stroke to calculate displacement would be appropriate.

P5 requires learners to verify calibration of machinery and equipment by using calculations. Learners are not required to undertake the calibration, but to check a calibration that has already been completed.

P6 requires learners to know which units are associated with which values. This could be linked to assessment of P1 or P3. Evidence could be an in-class test/examination or completion of a written assignment.

P7 requires learners to state how to use conversion tables. Evidence may be linked to that presented for P2, and may be in the form of a written assignment, test, question and answer session, poster or leaflet.

P8 requires learners to define the mathematical formulae for area, volume and circumference. Learners should know which formulae to use to work out the area, volume and circumference of different basic shapes as found in land-based engineering. Evidence may be presented in the same format as for P7.

P9 requires learners to know the relationship between speed and torque, which should include presentation of the appropriate formula together with a description of how an increase or decrease in speed affects torque. Evidence may be in the same format as for P7.

P10 requires learners to describe the formulae for power, torque, force, consumption and application rates. Evidence may be in the same format as for P7.

For P11, learners must describe the methods and equipment required to carry out a measuring task and the factors that can distort measurements. The measuring task may be chosen by the tutor or learner, but should be agreed before the start of the task and relate to the land-based engineering sector. Evidence may be in the same format as P7.

P12 requires learners to describe how to measure speed, velocity, acceleration, deceleration and coefficient of friction. This should be in a land-based engineering context and could be based on any practical investigations that learners have carried out. Evidence may be a written or verbal report, poster or leaflet.

For M1, learners are required to explain how the results of measurement and calculation tasks can be checked for accuracy. This explanation should include examples and specific detail about how these checks can be used. Evidence may be in the same format as for P12.

M2 requires learners to explain why calculated data may differ from measured results, and can be linked to P5 and P11. Learners should also suggest how the discrepancy between calculations and measurements of the same operation can be reduced, ideally to zero. Evidence may be in the same format as P12.

For D1, learners are required to discuss how given measurements and calculations are used in land-based engineering operations. The types of measurement and calculation should be provided by the tutor, and should relate to a minimum of four of those identified in the pass criteria. This requires learners to demonstrate their understanding of the practical application of mathematical concepts. Evidence may be in the same format as for P12.

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, P2, P3, P4, P5, P6, M1	Measurements and Calculations	You have been taken on by a land-based engineering workshop as a new trainee. In order to complete your probationary period you need to complete a workbook showing your ability to carry out measurements and calculations. Include notes which show how your results may be checked for accuracy.	Completed workbook.
P7, P8, P9, P10, P11, P12, M2, D1	Using Calculations in Land-based Engineering	To help those new staff working in the workshop, your supervisor has asked you to design two posters – one about measurement and one about calculations. Include an explanation of how calculations and measurements may differ, and how this can be resolved. The posters should show clearly a range of applications for calculations and measurements in land-based engineering.	

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 to most units in this specification and has particular links with:

Level 2	Level 3
LEO7 Core land-based engineering principles – calculations	Mathematics for Engineering Technicians

Essential resources

Centres should be suitably equipped to enable learners to have access to a range of measuring equipment. This should include pressure and flow measuring equipment, together with general measurement devices associated with engineering such as DTIs, vernier callipers and micrometers. A dynamometer would also be useful to demonstrate how to measure engine power output and consumption at various loads.

Employer engagement and vocational contexts

Learners could be introduced to a variety of professionals from different companies and organisations such as product designers, component testers, etc to broaden their knowledge and make the learning experience interesting and contextualised. This could be through guest lecturers or off-site visits to different establishments. A visit focusing on the quality control procedures of a manufacturing firm and the measurement techniques used would also help learners to appreciate the vocational significance of the unit.

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.ehow.com

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	taking measurements, calculating
Creative thinkers	describing calculations
Reflective learners	using theoretical methods to establish measurements
Team workers	recording data
Self-managers	using conversion tables
Effective participators	carrying out calibration exercises.

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 evaluating and carrying out extended thinking
Creative thinkers	asking questions to extend their thinking during lectures and practical sessions trying out alternatives or new solutions
Reflective learners	identifying opportunities for their own achievements
Team workers	assisting in group activities
Self-managers	setting own targets for accurate completion of work 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	designing tables to use in data recording
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	
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	using formula to establish measurements
Identify the situation or problem and the mathematical methods needed to tackle it	
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	taking part in group discussions.
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	