LEVEL 1/2 VOCATIONAL AWARD IN ENGINEERING (TECHNICAL AWARD)

GUIDANCE FOR TEACHING

UNIT 3 GUIDE

VERSION 2 – JUNE 2023

Aims of the Guidance for Teaching

The principal aim of the Guidance for Teaching is to support teachers in the delivery of the WJEC Level 1/2 Vocational Qualification in Engineering (Technical Award) and to offer guidance on the requirements of the qualification and the assessment process. The Guidance for Teaching is **not intended as a comprehensive reference,** but as support for professional teachers to develop stimulating and exciting courses tailored to the needs and skills of their own learners in their particular institutions.

Aims of the Unit Guide

The principal aim of the Unit Guide is to support teaching and learning and act as a companion to the Specification. Each Unit Guide will offer detailed explanation of key points in the Specification and aim to explain complex areas of subject content. An overview of the whole course can be found in the Delivery Guide.

Fig. 1

Contents

Introduction

The WJEC Level 1/2 Vocational Award in Engineering (Technical Award), approved by Ofqual and DfE for performance qualification tables in 2024 (first teaching from September 2022), is available to:

- all schools and colleges in England and Wales
- subject to local agreement, it is also available to centres outside England, for example in Northern Ireland, the crown dependencies of the Isle of Man and the Channel Islands, and in British overseas territories, and to British forces schools overseas. It is not available to other overseas centres.

It will be awarded for the first time in January 2024, using grades Level 1 Pass, Level 1 Merit, Level 1 Distinction, Level 1 Distinction*, Level 2 Pass, Level 2 Merit, Level 2 Distinction, Level 2 Distinction*.

Additional ways that WJEC/Eduqas can offer support:

- sample assessment materials and mark schemes
- exemplar materials
- face-to-face CPD events
- examiners' reports on each question paper
- direct access to the subject officer
- free online resources
- Exam Results Analysis
- Online Examination Review
- Regional Support team (England centres only)

Overview of Unit 3

Solving engineering problems

(40% of the qualification)

Overview of the unit

Unit 3 introduces learners to a range of considerations that impact on engineering design and how modern engineering has had an impact on modern day life at home, work and in society in general.

3.1	Understanding the effects of engineering achievements
3.2	Understanding properties of engineering materials
3.3	Understanding methods of preparation, forming, joining and finishing of engineering materials
3.4	Solving engineering problems

How to read the Specification

WJEC/Eduqas Vocational Award (Technical Awards) specifications are written to be transparent and easy to understand.

The amplification provided uses the following four stems:

- 'Learners should know' has been used for the recall of facts such as: legislation and definitions.
- 'Learners should know and understand' has been used for the majority of the unit content where knowledge needs to lead to a sense of understanding.
- 'Learners should be aware of' has been used when the volume of content is quite extensive, and learners do not need to understand all aspects in detail.
- 'Learners should be able to' has been used when learners need to apply their knowledge to a scenario or practical situation.

The amplification provided includes all of the assessable content for the relevant section, unless it states, *'e.g.' 'including'* or *'such as'*. In these cases, the amplification lists relevant content, which should be expanded upon in an appropriate way, taking account of learners' needs and interests. The use of the word '*including*' indicates compulsion (i.e. a question could be specifically set on that aspect). The use of the words *'e.g.'* or *'such as'* are for guidance only, and an alternative can be chosen.

UNIT 3 TEACHER GUIDANCE

1.1 Understanding the effects of engineering achievements		
	Content Amplification	**Teacher Guidance**
3.1.1	Learners should know and understand how engineering developments have an impact on the design of products and structures. These include developments in: • structural design, focusing on the development of bicycles • mechanical design, focusing on the development of theme park rides • electronic design, focusing on the development of mobile phone/smart technology.	Learners should know and understand how developments in engineering have affected the way that these three areas have evolved over time. **Structural Design** – Developments in lightweight materials have made bicycles more efficient by reducing weight and increasing structural strength. Development in brake, tyre and gear technology have all impacted on the cycling world. **Mechanical Design** – Engineering developments in theme parks have allowed far more immersive experiences for users, from the way that rides become more mechanically challenging in their range of motions to the interaction of digital content and animatronics. **Electronic Design** – Developments in mobile phone technology is fast paced and continually evolving, from connectivity such as conventional Wi-Fi and Bluetooth to emerging standards such as IFTTT to Smart home interaction and voice control. Social media and browsing, appliance connectivity and photo capability and screen development have all impacted on mobile phone development. Whilst this list is exhaustive, learners should explore the different contexts and applications of how this technology can be applied.

3.1.2	Learners should know and understand how the development of engineering products are impacted by changes in: • materials • smart technologies, including voice activated, Bluetooth and Wi-Fi • electronic and micro-electronic components and have affected modern life, including: • in the home • in society.	Learners should know and understand how the listed amplifications have been impacted by changes over time. For example: • Materials – improved strength to weight ratios, new alloys and smart materials. Improvements in plastics and textiles allowing for more diverse products and garments to be developed. • Smart Technologies – development in connectivity between appliances and the user, how smart homes can improve living quality for people at home and at work. • Electronic and micro-electronic components – allowing continued miniaturisation of devices and products, larger storage capabilities and faster processors, the inclusion of smart technology into more everyday devices making them more efficient and reliable. Learners should understand how the changes described have affected the development of engineering products that impact everyday homes, and the positive and negative impacts that have occurred in society as a result of these developments. Examination questions will be supported by a scenario and/or an image of an everyday product that learners will be familiar with. Learners will be expected to consider a specific aspect of the areas listed in the specification (as detailed above).

3.1.3	Learners should know and understand how the manufacture and use of engineered products have an environmental impact in terms of: • materials development • costs • transportation • their use • their disposal • recycling • sustainability. Learners should know and understand how environmental issues affect: • engineering processes • engineering products.	Learners should know and understand what impacts engineered products have on the environment across the lifespan of a product. **Materials development** – Development of the use of sustainable materials and the way in which improved recycling has an impact on the environment. The development of new natural and synthetic polymer-based materials reducing the need for petroleum-based polymers. **Costs** – Improved and more efficient manufacturing techniques reducing the overall cost of some materials where others are still quite volatile and dependant on price of raw material such as oil and ores. **Transportation** – The impact of the need to transport products globally and of how emissions impact the environment. **Their use** – How end users use and dispose of the products, and the impact on the environment. The ways in which countries approach sustainability and recycling. **Their disposal** – Looking at how different countries may approach the disposal of products after their failure or obsolescence. **Recycling** – Strategies for recycling products, where and how are they successful and where are they failing. **Sustainability** – Awareness that sustainability is the ability, in terms of both engineering processes and engineering products, to exist and develop without depleting natural resources for the future.

UNIT 3 TEACHER GUIDANCE

3.2 Understanding properties of engineering materials		
	Content Amplification	**Teacher Guidance**
3.2.1	Learners should know and understand the following materials and their properties, and when they should be used for a specific purpose. • Ferrous, e.g. mild steel, stainless steel, tool steel • non-ferrous, e.g. brass, copper, aluminium • thermoplastics, e.g. acrylic, nylon, HIPS • thermosetting plastics, e.g. urea formaldehyde, silicon • smart, e.g. thermochromic pigments/inks, shape memory alloy, nitinol wire • composite, e.g. carbon fibre, Kevlar.	Learners should know and understand the identified material properties and classifications listed in the amplification. They should be able to apply this knowledge to various engineered products to gain familiarity and understanding of where and why materials are used in certain situations. The smart materials highlighted in the adjacent content amplification should include a context or example of their use in everyday products/situations during their delivery to learners.
3.2.2	Learners should know and understand the physical properties of materials, including their: • tensile strength • compressive strength • hardness • toughness • malleability • ductility • conductivity • corrosive resistance • environmental degradation • elasticity and how they can be applied in an engineering context.	Learners should know and understand the terminology associated with the amplification list and how they apply in an engineering context. **Tensile strength** – The ability of a material to resist elongating or breaking when stretched. **Compressive strength** –The capacity of a material to withstand loads without deforming. **Hardness** – The ability of a material to resist deforming when impacted. **Toughness** – The ability of a material to absorb energy (impacts) before it deforms. **Malleability** – The ability of a material to be hammered, pressed or rolled into thin sheets. **Ductility** – The ability of a material to be drawn or plastically deformed without fracturing.

	Learners should know and understand the properties needed for the following engineering products: • mobile phones • security alarm found in the home • bicycles • children's play areas.	**Conductivity** – The measure of how efficiently electricity or heat can pass through a material. **Corrosive resistance** –How well a material can withstand damage caused by oxidization or other chemical reactions. **Elasticity** – The ability of a material to resist a distorting effect and to return to its original size and shape. **Environmental degradation** – How the environment is degraded or compromised through a range of situations such as air pollution, deforestation, water contamination etc.
3.2.3	Learners should know and understand how destructive testing (DT) and non-destructive testing (NDT) is undertaken to determine physical properties of engineering materials, including: • tensile strength • hardness • toughness • malleability • ductility • conductivity • elasticity.	Learners should know and understand how testing is undertaken to determine the physical properties of materials. Learners should understand the difference between destructive and non-destructive testing.

UNIT 3 TEACHER GUIDANCE

3.3 Understanding methods of preparation, forming, joining and finishing of engineering materials		
	Content Amplification	**Teacher Guidance**
3.3.1	Learners should understand processes, including relevant tools and equipment, used to produce engineering products including: • marking out • cutting • finishing • preparing • shaping • drilling • turning • brazing • joining – permanent and temporary fixings • filing • soldering.	Learners should understand the terms and operations of the amplifications listed. Learners should be familiar with describing the processes and what tools and equipment are required to achieve them. Learners should also be aware that some items of equipment are capable of multiple tasks i.e., a lathe or miller. Joining should include riveting, brazing and welding for permanent joints and for temporary, mechanical fixings should be included.
3.3.2	Learners should understand how engineering processes can be used for: • material removal • shaping and manipulation • joining and assembly • heat and chemical treatment.	Learners should understand the main engineering processes including the use of hand tools and equipment, such as: • material removal – sawing, filing, milling, turning • shaping and manipulation – milling, turning, filing, bending, compressing, forming • joining and assembly – adhesives, welding, screws nuts and bolts etc • heat and chemical treatment – annealing, normalising, tempering and hardening; etching, electroplating, galvanising and anodizing.

3.3.3	Learners should know and understand how to work safely when working in an engineering environment such as a school/college workshop when preparing, using and finishing materials, including by: • carrying out a risk assessment • identifying risks • identifying appropriate control measures.	Learners should know and understand how to perform a risk assessment on a range of tasks in a school or college workshop. Risk assessments should be based on the tools and equipment available in those facilities. This reinforces content taught in Unit 1, section 1.3.3 (Health and Safety).

UNIT 3 TEACHER GUIDANCE

3.4 Solving engineering problems		
	Content Amplification	**Teacher Guidance**

3.4.1	Learners should know and understand and be able to use calculations and mathematical techniques that are required to solve engineering problems, including:
	• use of formulae
	  • Ohms law
	  • mechanical advantage
	  • velocity ratio
	• areas and volumes
	• measuring using datums
	• estimation (of cost/materials)
	• average
	• scale (enlargement and reduction)
	• units of measurement including:
	  • metric (e.g. metres, millimetres)
	  • imperial (e.g. feet, inches)
	• time conversion (hours, minutes & seconds)
	• graphs – histogram, bar charts, line graph, pie charts.
		Learners should know and understand the amplification list as they appear in a number of areas in Units 1 and 2.
		Again, the amplifications link to possible tasks within the Unit 2 brief and could form a part of an assessment in either the brief for Unit 2 or as an examination question in Unit 3.
		The 3.4.1 amplifications can be delivered using a holistic approach and do not need to be focused on as individual topics. For example, using a wind-up torch, learners can disassemble the product, and focus on the internal circuitry, charging mechanism and general properties of the product. Learners could also produce their own orthographic drawings of the product.

3.4.2	Learners should understand the following technical details in an engineering drawing: • section views • construction lines • centre lines • hidden details • standard conventions • datums. Learners should be able to interpret and produce a range of engineering drawings including: • third-angle orthographic projections • isometric views • sectional views that include technical details such as: • dimension lines sectional lines.	Learners should understand the key parts of engineering drawings as they are issued to learners in Unit 1 and are required to be produced by the learner in Unit 2. Learners should be familiar with the correct layout of orthographic views, constructing isometric views from orthographic details and vice versa, and should be able to identify the correct form of line i.e., construction line or centre line, and should be familiar with the use of hidden detail in an engineering drawing. Learners should also have an understanding of the use of sectional drawings to convey detailed information about the component parts found in an engineered product.

CREATE YOUR OWN EXAM QUESTIONS

When you are helping your learners prepare for Unit 3, you will find using the questions in the sample assessment materials (SAMs) useful. However, we appreciate that at the start of a course you might want to have a bigger bank of questions to use with your learners. Therefore, you might find it useful to create some of your own. You might even decide to get your learners to write their own questions and mark schemes. This step-by-step guide will help you to create your own exam papers.

All exam questions have three core elements:

A command word + **Link to the specification content** + **A tariff**

What do you need to know about the core elements?

Command word	1. Must be appropriate for the task. 2. Must be linked to the assessment objective. 3. Are often linked to the question's tariff.	1. Is it clear to the learner what they are expected to do in order to access the full range of the mark scheme? 2. If the question is targeting more than one assessment objective, more than one command word must be used. **A full table of how command words relate to assessment objectives is available in the 'Assessment Guide'.** 3. For example, commands words such as 'state' and 'name' should be reserved for lower tariff questions, whereas 'analyse' and 'explain' are often better for higher tariff questions.
Link to the specification content	1. The question must ask the learner about content listed in the specification only. 2. The link to the specification must be clear and unambiguous.	It should be clear which area/s of the specification are being targeted. Consider the stem of the specification content and this will indicate the depth the learner should know and understand the content.
Tariff	1. Must be appropriate for the command word used. 2. Must be appropriate for what is being assessed. 3. Must be accessible for level 1/2 learners within an exam context.	1. It should be possible and clear to the learner how they can achieve all of the marks available for any question: the higher the tariff, the longer the learner should take to answer the question. A good starting point is to allow one mark per minute. 2. Use the SAMs as a guide for what is an appropriate tariff and about the range of tariffs used across a whole paper.

Describe the difference between a destructive test and a non-destructive test. [2]

Command word

Unambiguous link to specification

Tariff

There are some additional elements that some exam questions use:

Context	Sometimes, it is useful or necessary to provide learners with a context to which they will apply their knowledge and understanding of a particular topic.	A context should be written clearly and using language that is as simplistic as possible. The context should be concise and should provide only the information that learners will need to answer the question. Additional information may be time-consuming or misleading. It should depict something that learners will understand, rather than something that is unfamiliar or confusing. **Examples of questions in the Unit 3 SAMs that use a context is question 3d.**
Stimulus	Sometimes learners may be provided with a stimulus. The stimulus might be an image, data in the form of a graph or a table, or something else.	Ay stimulus must be clear and should not provide information that is excessive or irrelevant. If the stimulus is an image, it should be clear, an appropriate size and of good quality. **An example of a question in the Unit 1 SAMs that uses a stimulus is question 1.**

Assessment Objectives

Each question should target an assessment objective which is signalled by the command word. If more than one Assessment Objective is targeted, more than one command word should be used.

A full table of the assessment objectives that have been set for all our Vocational qualifications is available in the 'Assessment Guide'. However, what does each assessment objective require learners to do?

AO1	Requires learners to recall the knowledge that they have learned throughout their course.
AO2	Requires learners to: • use learned material in a new situation with a minimum amount of help or direction. • apply rules/principles to a problem, without being given the rule; problem solving.
AO3	Requires learners to: • break material into component parts so that its structure may be understood • break complex concepts down to component parts and analyse how parts are related to each other; seeing patterns, recognising hidden meanings • judge the value of material based on certain criteria • evaluate, make judgments on the worth of a concept for a purpose • resolve controversies/differences of opinion • verify value of evidence • recognise subjectivity.

What type of question should be used?

There are several ways to ask a question, and you should consider what is most appropriate for the question that you're asking. Some guidance is given below:

Matching pairs Multiple choice True or false	These styles of question are useful for asking questions that have answers that are predetermined, usually assessing straightforward knowledge and understanding (AO1).	These questions should be marked objectively, in that there is a correct and an incorrect answer.
Short Answer	These can be open-ended and require learners to construct a short answer. They are low tariff, and usually used to test knowledge and understanding. Short answer questions are also used for calculations and data manipulation.	This type of question could be marked objectively if there is one or several correct that might be given. However, if the candidate is required to construct a response, it may be that subjectivity is required to decide whether a number of marks maybe given according to the accuracy and quality of the response, as permitted by the tariff. **For an example, see question 1c on page 5 of the Unit 3 SAMs.**
Extended answer	This allows learners to respond at length to open-ended questions. In this, learners may be required to organise their ideas, to build an argument, and may result in a range of interpretations that draw upon wider and more flexibly defined sources. These are usually used to test higher skills, writing and structuring skills, further reading and a deeper level of understanding.	These questions will be marked subjectively: you should use your judgement to place learners' responses into bands that detail criteria that responses should meet. **For an example, see question 4 on page 18 of the Unit 3 SAMs.**

Problem solving	These require a range of critical thinking skills from identification, description and analysis, to synthesis and evaluation. Sometimes there will be exact or correct answers to problems – as in answering maths problems – or sometimes learners may be asked to propose and justify a course of action to address a specified situation, or to develop a well-reasoned explanation or response based on data analysis, models or precedent.	Questions that require exact or correct answers should be marked objectively, in that there is a correct and an incorrect answer. **For an example, see question 2d on page 10 of the Unit 3 SAMs.** Questions that require a proposed or justified course of action will be marked subjectively; you should use your judgement to place learners' responses into bands that detail criteria that responses should meet.
Graph production or interpretation	Graph production questions involve both numerical/mathematical skills. Graph interpretation questions involve both numerical/mathematical skills as well as reasoning skills.	These questions should be marked objectively, in that there is a correct and an incorrect answer.

Golden Rules:

1. Try and keep questions as short and clear as possible.
2. Consider splitting long questions into a statement and a question.
3. Avoid asking more than one question in a sentence.
4. Use plain English, e.g., *buy* rather than *acquire*.
5. Avoid using:
   a. negatives (where possible)
   b. technical language (unless it is part of what is being assessed)
   c. idioms/metaphors/non-literal use of language, e.g., see eye to eye, cut back on, branching out
   d. words that have more than one meaning, e.g., volume, fit, illustrate (unless it is part of what is being assessed)
   e. gender-biased words, e.g., chairman, manmade, policewoman.
6. Across a whole paper, questions should increase in difficulty. Higher tariff questions are more likely to be found towards the end of the paper.
7. A whole paper should sample a wide range of specification content. You might find it useful to use a blank version of the tracking grid from the SAMs (page 39).

Terminal Rule

Key Principles:

Candidates must take the external assessment, worth 40% of the qualification, in the series in which they certificate.	Only the result for the external assessment that is achieved in the final series, the series in which candidates 'cash-in', can contribute to their final grade. If a candidate takes the external assessment prior to the series in which they 'cash-in', this result cannot contribute to the overall grade, even if it is the better result.	In relation to school performance table points – as opposed to individual candidate results – it is always the first qualification result which counts, irrespective of whether a candidate re-certificates again at a later date.

- Candidates can enter for internally assessed units in January and June
- Candidates may resit each **internally** assessed unit but cannot improve previously submitted work. The best uniform mark score from the attempts will be used in calculating the final overall grade.

Example scenarios (assuming that the delivery of the qualification takes place over two years):

Scenario 1:

Year 1 January	Year 1 June	Year 2 January	Year 2 June
No entries	Entry of **internal** assessment	Entry of **internal** assessment	Entry of **external** assessment **Cash in**

✓ Entry for external assessment takes place in the same series as cash-in and certification.

Scenario 2:

Year 1 January	Year 1 June	Year 2 January	Year 2 June		
No entries	Entry of **external** assessment	Entry of **internal** assessment	Entry of **internal** assessment **Cash in**	☒	Entry for external assessment **does not** take place in the same series as cash-in and certification.

Scenario 3:

Year 1 January	Year 1 June	Year 2 January	Year 2 June		
No entries	Entry of **internal** assessment/s	Entry of **external** assessment	Entry of **external** assessment **Cash in**	✓	It is the **second** attempt of the external assessment that will count towards the final grade, even if it is lower than the previous attempt.

Scenario 4:

Year 1 January	Year 1 June	Year 2 January	Year 2 June		
No entries	No entries	Entry of all **internal** and **external** assessments **Cash in**	No entries	✓	This is a linear approach and would be permissible if the qualification was completed in either January or in June.

Assessment of Unit 3

Unit 3: Solving Engineering Problems
Written examination: 1 hour 30 minutes
40% of qualification

80 marks: 120 UMS

An assessment comprising of a range of question types to assess specification content related to ideas and concepts in Engineering.

All questions are compulsory.

The assessment objective weightings for Unit 3 are:

AO1	AO2	AO3
20%	15%	5%
40 marks	30 marks	10 marks

FAQs

Can learners resit the Unit 3 assessment?

Candidates may resit the **externally** assessed unit, prior to certification; however, this qualification has a 40% terminal requirement which must be satisfied by the externally assessed unit. Therefore, only the uniform mark score from the attempt made in the series in which the candidate is cashing in the qualification will be used in calculating the final overall grade, even if this is lower than the previous attempt.

Candidates who are unhappy with the grade awarded for the qualification may choose to resit one or more units following certification.

Where the candidate resits the externally assessed unit, only the uniform mark score from the resit attempt will be used in calculating the final overall grade, even if this is lower than the previous attempt. The candidate does not need to resit the internally assessed unit as marks for the internally assessed unit may be carried forward for the lifetime of the specification.

What is the entry code for this unit?

		Entry Code
Unit 3	External	5799UB
Cash in code		5799QA

Is this assessment compulsory?

Yes.

When can candidates sit the Unit 3 assessment?

Assessment opportunities will be available in January and May/June each year, until the end of the life of this specification. January 2024 will be the first assessment opportunity for Unit 3.

Are candidates assessed on their spelling, punctuation and grammar in this assessment?

No, although learners are reminded of the need for good English and orderly, clear presentation in their answers.

Will candidates be expected to answer questions about content in Unit 1 or Unit 2 in this exam?

Yes. At least one question in the exam will provide an opportunity for candidates to draw together knowledge and understanding from across the full course of study. Candidates will be rewarded for drawing together knowledge and understanding of different areas of the specification.

Will the assessment objective weightings remain the same throughout the life of the specification?

Yes.

How is the unit reported?

This unit will be graded Level 1 Pass, Level 1 Merit, Level 1 Distinction, Level 1 Distinction*, Level 2 Pass, Level 2 Merit, Level 2 Distinction, Level 2 Distinction*.

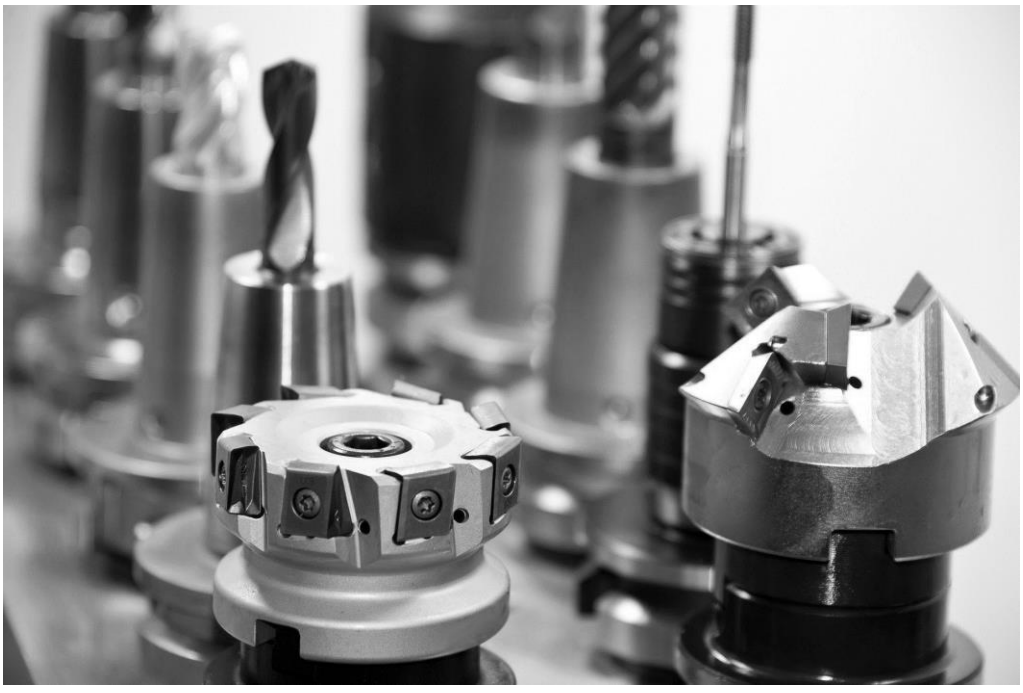

Fig.2

GLOSSARY FOR UNIT 3

Term	Definition
Destructive and non-destructive testing	A range of methods used to test individual parts or complete products to determine performance or material behaviour.
Electronic Design	The design and development of electronic systems such as printed circuit boards (PCB's) and integrated circuits in products etc.
Engineering drawing	Engineering drawings, for the purpose of Unit 3, are the drawings which learners produce as a part of their response for explaining their engineering solution in detail. They include Orthographic and Isometric views detailed below as well as dimensional (size) details, information on finishes and tolerances etc. These can be produced traditionally using a drawing board or by CAD methods using suitable software.
Isometric Views	A measured three-dimensional view or representation of a part or product. They are constructed using 30° (or 30°/60°) grids.
Mechanical Advantage	The advantage gained by using a mechanism in transmitting force such as a cantilever to raise heavy objects.
Mechanical Design	The design of components and systems of a mechanical nature such as machines, products and instruments.
Ohms Law	A law which states that for any electric circuit, the electric current is directly proportional to the voltage and is inversely proportional to the resistance (V=IR).
Orthographic View	This is the standard set of views used in an engineering drawing to display sizes and details about a product. Typically, views would include a front, end (side, sometimes left and right) and a plan (top) elevation (or views).
Smart Technologies	Materials that have properties which allow them to change reversibly depending on their environment or physical stimulus.
Structural Design	The design of structural elements in buildings and products. Structural design focuses on strength and rigidity and involves the use of science and mathematics to calculate outcomes.
Sustainable Materials	Materials which have a relatively positive impact on both communities and the environment that are used to build products, services and buildings.
Velocity Ratio	A ratio of the distance that the effort must move and the distance that the load moves.