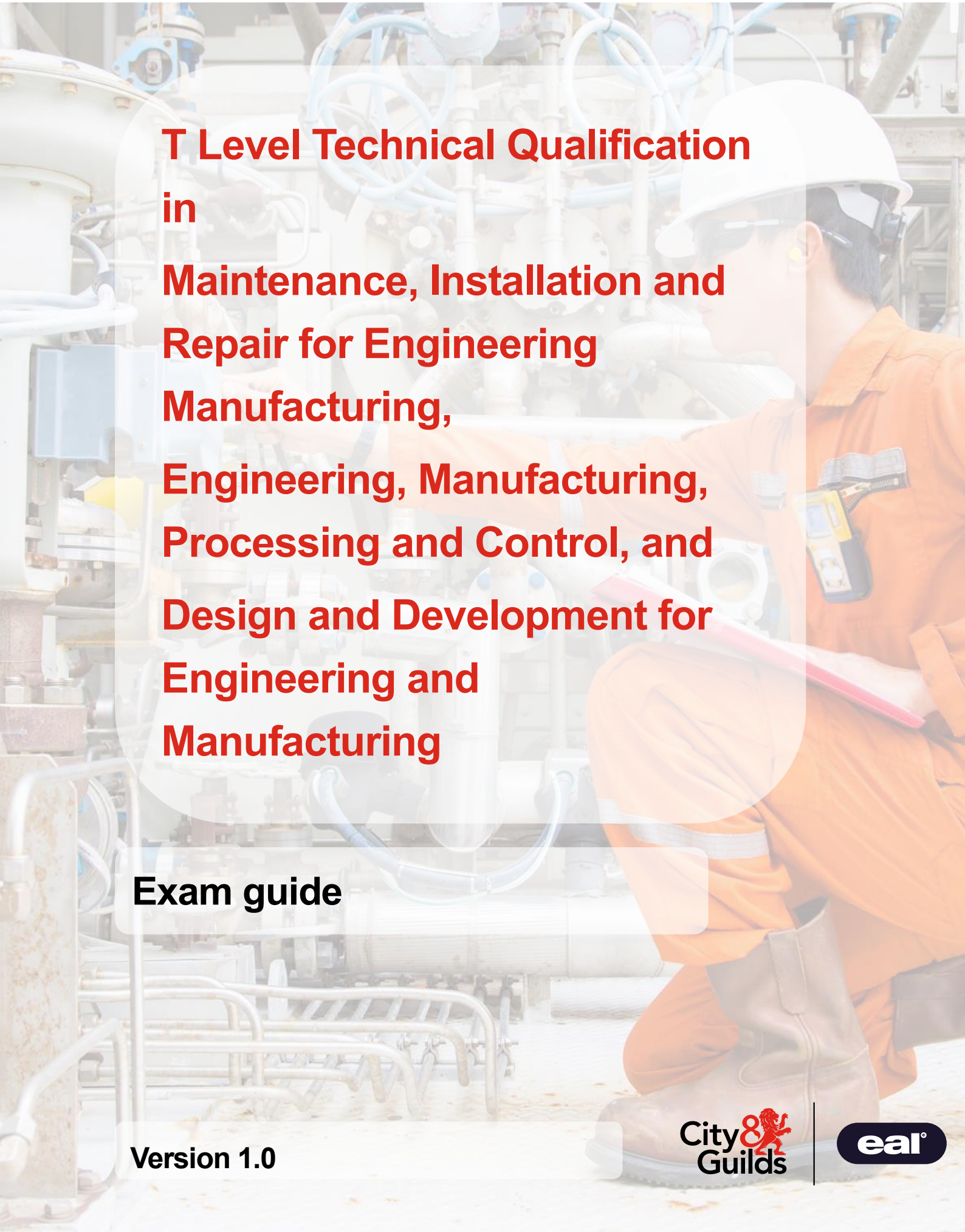
T-LEVELS | Institute for Apprenticeships & Technical Education



T Level Technical Qualification in Maintenance, Installation and Repair for Engineering Manufacturing, Engineering, Manufacturing, Processing and Control, and Design and Development for Engineering and Manufacturing

Exam guide

Version 1.0

City & Guilds | eal

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1. Introduction

This exam guide for the T Level Technical Qualification in Maintenance, Installation and Repair for Engineering Manufacturing, Engineering, Manufacturing, Processing and Control, and Design and Development for Engineering and Manufacturing core exams (Paper 1 and Paper 2) provides general tips for candidates taking these assessments, along with examples of different types of questions that will appear. Example candidate responses have also been provided along with examiner commentary and further hints and tips. The example candidate responses should not be considered as the only or best way to answer the question, their aim is to support transparency of the expectations when candidates are responding to different types of questions.

Marks, as indicated by “(1)”, highlighted in yellow have been added to show where marks have been awarded to support transparency of marking, they were not part of the candidate’s response.

2. General Tips

- Spelling, Punctuation and Grammar (SPaG) are not assessed within the core exam, no marks are awarded or deducted based on this. Examiners will make a judgement in relation to phonetic spelling to determine if the candidate has the required knowledge and/or understanding and where there is credit will award the mark(s).

  Handwriting quality, it is key that the candidates provide responses which are legible. Examination papers are scanned and marked onscreen therefore it is critical that candidates respond to questions using a ball-point pen and ensure their writing is legible. A recommendation would be to use block capitals if handwriting is poor or explore using a scribe.

  It is key candidates understand the paper is split into two sections (Section A and Section B) and they understand the type of questions they will find in each part of the paper. This can help them with time management ensuring they leave sufficient time to respond to the Extended Response Questions within Section B.

- The order of the paper is modelled in a way so that it gradually increases in level of difficulty. The paper starts with Section A with questions assessing knowledge, before moving onto understanding, then application. Section B then assesses application, analysis and evaluation.

- It is important that candidates carefully read and understand the question, reading it through twice if needed.

- For Paper 1 candidates are permitted to use a formula sheet. This will be supplied alongside the question paper. A copy of this formula sheet is available on the 8730 webpage. This formula sheet will contain the same formulas each series, unless a newer version is issued in which case providers will be informed well in advance of the assessment to support exam preparation. Candidates may not need to use all of the formula within one examination series.

3. AO1a – Demonstrate Knowledge

What this assessment objective means

Recall or recognition of specific elements of knowledge which must be committed to long term memory in order to underpin success in the role.

All Assessment Objectives require the ability to recall knowledge. AO1a) refers to instances where the candidate is simply required to demonstrate basic recall. In the exam, this helps to give confidence in sufficiency of coverage of the content, and recognises that not all knowledge requires further understanding eg terminology, number facts etc.

A candidate can

- name or recognise technical terms, principles theories, based on a description/use or vice versa
- distinguish between correct and incorrect definitions/descriptions
- correctly use terminology/terms
- locate a part on a diagram.

This is assessed within the examination by

Simple questions that require knowledge that could be learned by rote (facts) no requirement to go beyond recall and statement of fact:

- Labelling a diagram with names/locations
- Definitions, facts, recall of purpose of something
- Description of physical appearance of something.

3.1. Question and Mark Scheme

<table>
<tr><td rowspan="3">Q 1</td><td>Stem</td><td colspan="2">State Kirchhoff's laws for:
a) current (1 mark)
b) voltage. (1 mark)</td></tr>
<tr><td colspan="2">Acceptable answer(s)</td><td>Marking Guidance</td></tr>
<tr><td colspan="2">a) Total current entering and exiting/leaving a node/junction must always equal zero [1].
Or presented as a formula:
$$\sum_{i=1}^{n} I_i = I_1 + I_2 + I_3 = 0$$
Or
$$I_{Total} = I_1 + I_2 + I_3 \ldots$$
Or
$$\sum(Entering\ currents) = \sum(leaving\ currents)$$
b) the sum of all the voltage drops around a loop is zero [1].
Or presented as a formula:
$$V_1 + V_2 + V_3 + .. - V_s = 0$$
Or
$$V_s = V_1 + V_2 + V_3 + ..$$
Or
$$\sum(voltage\ rise) = \sum(voltage\ drop)$$</td><td>Candidate wording may differ to those given in the acceptable answers. This should still be credited when correct.
Award full marks if correct algebraic equations or formulas are provided instead of definitions.
Award full marks if the correct algebraic equation holds.</td></tr>
<tr><td>Total Marks</td><td colspan="3">2</td></tr>
<tr><td>Element</td><td colspan="3">8 Electrical and electronic principles</td></tr>
<tr><td>Specification reference</td><td colspan="3">8.1 Kirchhoff's current and voltage laws
The definitions of terms used in electric circuit theory and their applications</td></tr>
</table>

3.2. Candidate Responses

Example 1 (Marks 1, 1)

a) Sum currents entering loop is equal to the sum currents leaving the circuit.
b) Sum of voltage is equal to voltage drops across circuit $V = V_1 + V_2 + V_3 + ..$

Examiner Commentary on application of mark scheme

Candidate recalls the correct definitions of Kirchhoff's law as outlined in the mark scheme. Marks are achieved for both parts.

Example 2 (Marks 0, 1)

a)
b) $V_1 + V_2 + V_3 - V_s = 0$

Examiner Commentary on application of mark scheme

Candidate left part a) blank, therefore 0 marks are awarded, however, is able to define Kirchhoff's law of voltage expressed by a formula therefore achieves 1 of the available 2 marks.

Example 3 (Marks 0, 0)

a) $R = \frac{I}{V}$
b) $V = IR$

Examiner Commentary on application of mark scheme

Candidate has attempted to recall Ohms law rather than Kirchhoff's. This has also been recalled incorrectly for part A. 0 marks are awarded for both parts.

3.3. Examiner Hints and Tips

- Often candidates struggle to achieve marks in relation to AO1a as they don't have the knowledge the question is targeting, meaning they do not have a secure breadth of knowledge across the syllabus. Candidates may either leave the question blank or will recall an incorrect fact, acronym or name.
- When asked to recall legislation or regulations, examiners will accept industry recognised abbreviations and acronyms, as shown in the marking scheme.
- Examiners will also except alternative answers, if acceptable within the marking guidance. For example, descriptions of terms or definitions displayed via a formula.
- Where a candidate does not know the answer, or is unsure, they should be advised to leave these questions and come back to them once they've completed the rest of the paper.

4. AO1b – Demonstrate Understanding

What this assessment objective means
The ability to explain principles and concepts beyond recall of definitions in order to be able to transfer these principles and concepts between contexts. Candidates have built connections between related pieces of knowledge.

AO1b) focuses on the ability of the candidates to show understanding by summarising or explaining concepts in their own words, exemplifying or comparing and making inferences in general terms that show eg cause and effect.

A candidate can

- explain a concept in their own words
- explain what it means in practice
- give relevant examples
- say what the impact/implication may be in general terms

This is assessed within the examination by
Straightforward questions requiring demonstration, beyond recall, of understanding about something. Response is in general terms, or a concrete exemplification.

- Why is..
- What does … mean?
- Explain the use of…
- Explanation of how something works
- Explanation of the benefits/weaknesses of…

4.1. Question and Mark Scheme

<table>
<tr><td rowspan="3">Q5 b)</td><td>Stem</td><td colspan="2">Explain two characteristics of a circuit diagram.
(4 marks)</td></tr>
<tr><td colspan="2">Acceptable answer(s)</td><td>Marking guidance</td></tr>
<tr><td colspan="2">• Shows individual components [1] which differs to a diagram/block diagram that shows groups of components [1].
• Uses standard symbols [1], to show which components are being represented to others, regardless of their language/job role [1].
• Represents wires as straight lines [1], which allows the physical connections between components to be easily understood [1].
• Shows the layout of a circuit [1] to help the reader to understand how it functions [1].</td><td>Award 1 mark for each characteristic, with a second mark for the supporting/linked explanation, up to a maximum of 4 marks.

Only accept the <u>first two characteristics</u> written by the candidate.</td></tr>
<tr><td>Total marks</td><td colspan="3">4</td></tr>
<tr><td>AO</td><td colspan="3">AO1b = 4</td></tr>
<tr><td>Specification reference</td><td colspan="3">3 Engineering representations
3.1 Drawings and information conveyed by drawings.
3.1.1.8 - circuit diagrams
The characteristics of, purposes of, and audience for different drawing types.</td></tr>
</table>

4.2. Candidate Responses

Example 1 (4 marks)

Circuit diagrams have engineering drawing symbols (1) allowing people to see what components are in the circuit using a format which is recognisable to all (1). Circuit diagrams show the layout of the circuit (1) allowing people to see where everything goes (1).

Examiner Commentary on application of mark scheme

Marks were awarded as follows:

1. Point: *they use engineering drawing symbols*, this is a correct characteristic of a wiring diagram.
2. Expansion: *which are recognisable to all*, this is a valid expansion / linked explanation of the characteristic.
3. Point: *they show the layout of the circuit*, this is another correct characteristic of a wiring diagram
4. Expansion: *allowing people to see where everything goes,* this is a valid expansion / linked explanation of the characteristic.

Example 2 (3 marks)

A circuit diagram uses simple symbols (1). These allow everyone to read the diagram with ease (1). A circuit diagram tends to show wires as straight lines (1), making the circuit rectangular in shape making it easier to read.

Examiner Commentary on application of mark scheme

Marks were awarded as follows:

1. Point: *they use symbols*, this is a correct characteristic of a wiring diagram.
2. Expansion: *which allows everyone to read the diagram with ease*, this is a valid expansion / linked explanation of the characteristic.
3. Point: *They show the wires as straight lines*, this is another correct characteristic of a wiring diagram

Marks were not awarded for:

- Expansion: *making it easier to read,* this is a repeat of the point the candidate has already made and been awarded a mark for.

Example 3 (2 marks)

A circuit diagram shows the layout of a circuit (1), so engineers have a clear visual representation of it (1). It also clearly shows the current flowing around the circuit so they can do any calculations that are necessary.

Examiner Commentary on application of mark scheme

Marks were awarded as follows:

1. Point: *they show the layout of the circuit*,, this is a correct characteristic of a wiring diagram.
2. Expansion: *which gives a clear visual representation* this is a valid expansion / linked explanation of the characteristic.

Marks were not awarded for:

- Point: *shows the current flowing around the circuit*, this is not an accurate characteristic of a wiring diagram
- Expansion: *so they can do any calculations that are necessary,* this is not an accurate expansion.

Example 4 (1 mark)

A circuit diagram will show the components (1) like where the battery is or where the motor is. Also, the circuit diagram will show you the voltage.

Examiner Commentary on application of mark scheme

Marks were awarded as follows:

1. Point: *show the components* this is a correct characteristic of a wiring diagram.

Marks were not awarded for:

- Expansion: < *blank*> There is no expansion / linked explanation of the characteristic given.
- Point: *show you the voltage*, this is not an accurate characteristic of a wiring diagram
- Expansion: < *blank*> There is no expansion / linked explanation of the characteristic given.

4.3. Examiner Hints and Tips

- In questions such as this, candidates should take the approach of stating their point, then expanding on why this is helpful/important in the context of the question posed. Using connects such as 'which' or 'so' to show cause and effect.
- Using this model and understanding of the mark scheme candidates can understand how to structure their answer. In this example they get a point for identifying a characteristic of a wiring diagram, the 2nd and 4th mark then comes from the linked explanation/expansion of this characteristic.
- Some questions may give the candidates the point and ask the 'why' meaning the question is looking for them to explain/expand only.

- Candidates must ensure they have also considered the context given within the question. Candidates will only achieve marks when they identify characteristics relevant to the context given i.e. a circuit diagram.
- By just listing out characteristics with no further explanation, candidates will not be able to achieve full marks as they have not demonstrated they understand what this characteristic is used for/does.

5. Mathematical Questions (AO1b/AO2)

Paper 1 consists of a significant amount of mathematical and scientific principles that underpins theories of engineering.

There is no set amount of mathematical style questions or marks for each paper, but they will always feature as a part of the question paper therefore its important candidates understand how the mark scheme works.

The questions will be as transparent as possible around what we need the candidate needs to demonstrate they know/understand.

For example; some questions may explicitly state the mathematical method we want to see (to assess understanding of that method) whereas other may need the candidate to determine the mathematical method from the context of the question (to assess ability to apply mathematical concepts to a particular context).

Candidates will be told to show their workings where method marks are awarded.

In some instances candidates may be asked to provide the relevant unit of measure for their answers, whereas in other questions this may be given to the candidate on a response line.

Within questions which require a mathematical solution, each mark will be labelled as either M, A or B:

- M = Method marks for the use of the correct method. These should be awarded when a suitable method has been selected and applied to show that the method has been understood. Method marks are not usually lost for numerical errors, or errors in units.

- A = Accuracy marks for accurate workings/answers. These should be awarded for a correct answer or intermediate steps correctly calculated.

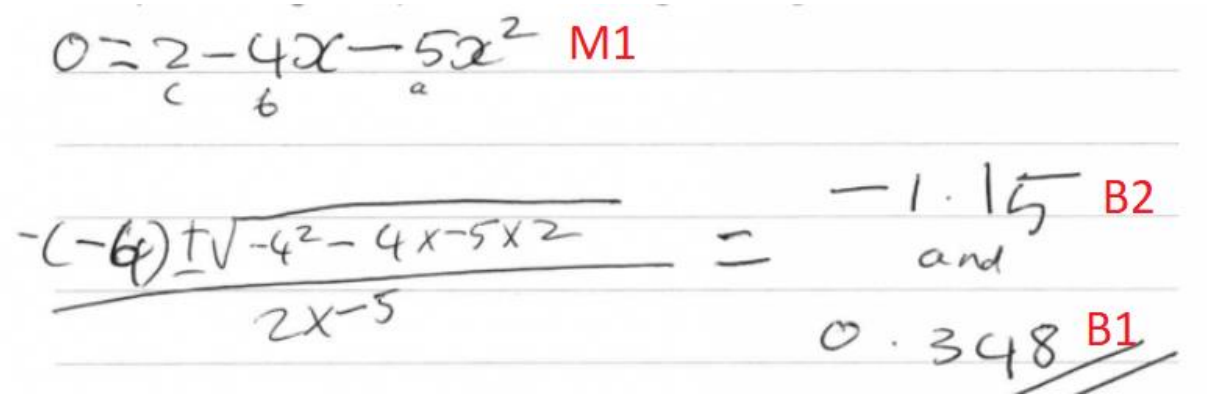
- B = This mark is for method and accuracy combined. This is when a mark may not be needed for methodology where it is straight forward arithmetic or use of a calculator.

5.1. Question and Mark Scheme

<table>
<tr><td rowspan="4">Q12</td><td>Stem</td><td colspan="2">The output from an electrical device is represented by the equation:
$5x^2 = 2 - 4x$
Determine the two possible values of x.
Show your workings. Give your answers to 3 significant figures.
(3 marks)</td></tr>
<tr><td colspan="2">Acceptable answer(s)</td><td>Marking Guidance</td></tr>
<tr><td colspan="2">$5x^2 + 4x – 2 = 0$ [M1, 1, AO2]</td><td>M1: Award 1 mark for rearranging to a quadratic equation.</td></tr>
<tr><td colspan="2">Using $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$
$x = \frac{-4+\sqrt{4^2-4\times5\times-2}}{2\times5}$
$x = \frac{-4+\sqrt{56}}{10}$
x = 0.348 [B1, 1, AO2]</td><td>B1: Award 1 mark for correct method & answer.
Accept values between 0.348 to 0.35.</td></tr>
<tr><td colspan="2">$x = \frac{-4-\sqrt{4^2-4\times5\times-2}}{2\times5}$
$x = \frac{-4-\sqrt{56}}{10}$
x = -1.15 [B2, 1, AO2]</td><td>B2: Award 1 mark for correct method & answer. Accept values between -1.148 to – 1.15.
Alternative methods can be accepted.
SI unit not applicable.
Award full marks even if answer is not provided to 3 significant figures.</td></tr>
<tr><td>Total Marks</td><td colspan="3">3</td></tr>
<tr><td>AO</td><td colspan="3">AO2</td></tr>
<tr><td>Element</td><td colspan="3">4 Essential Mathematics for engineering and manufacturing</td></tr>
<tr><td>Specification reference</td><td colspan="3">4.1.2.2 Applied mathematical theory in engineering applications – solve simultaneous and quadratic equations</td></tr>
</table>

5.2. Candidate Responses

Example (3 marks)



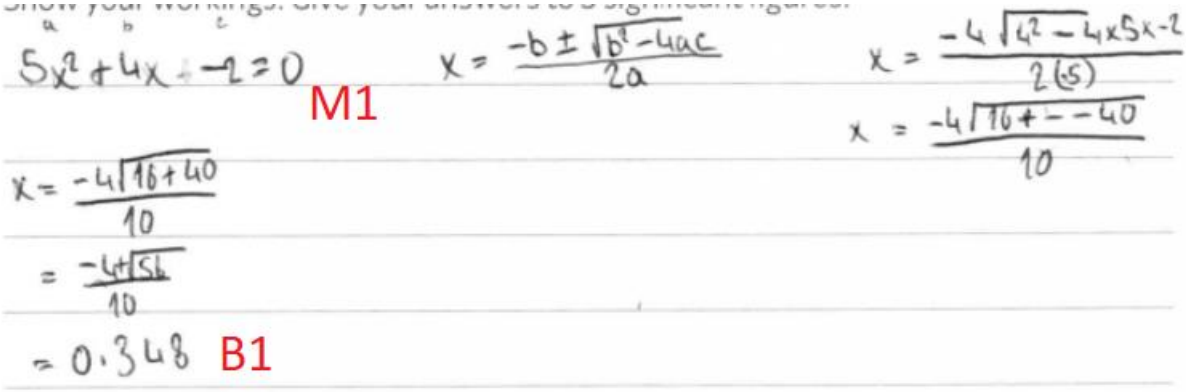
Examiner Commentary on application of mark scheme

M1: Whilst the candidate has chosen to move the equation in the opposite direction to the mark scheme, they have still demonstrated they need to make the equation quadratic.

B1: They have demonstrated how they've used the quadratic equation and given an answer within the given range.

B2: They have demonstrated how they've used the quadratic equation and given an answer within the given range.

Example (2 marks)



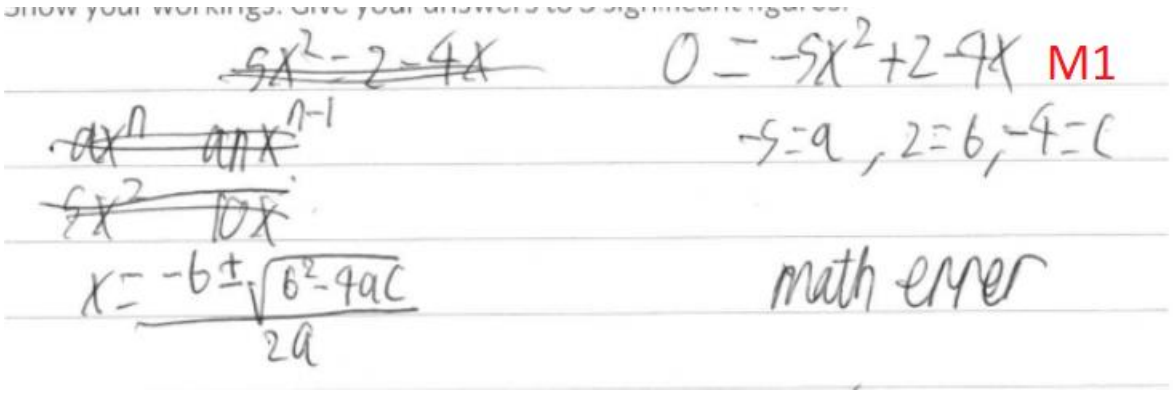
Examiner Commentary on application of mark scheme

M1: The candidate has made the equation quadratic.

B1: They have demonstrated how they've used the quadratic equation and given an answer within the given range.

B2: They have not calculated what X would be if the square root was taken away from b.

Example (1 mark)



Examiner Commentary on application of mark scheme

M1: Whilst the candidate has chosen to move the equation in the opposite direction to the mark scheme, they have still demonstrated they need to make the equation quadratic.

B1 and B2: Despite identifying a, b and c from the equation, the candidate has been unable to use the quadratic formula to determine either value for x.

5.3. Examiner Hints and Tips

- Encourage candidates to always show their workings on mathematics questions, they may be able to pick up marks for following the correct method, even when calculations have gone wrong.
- If candidates only present an answer and do not show the method that they used for the calculation, they may not achieve full marks.
- Where candidates make errors in their calculations or the method used, they should cross through their workings.
- Candidates should note the SI unit/unit of measure that their answer needs to be presented in.
- Candidate should note the number of decimal places or significant figures they are asked to give their answer too.
- Candidates should ensure any workings out are clear and are presented in a logical order.

6. AO2 – Apply Knowledge and Understanding to Different Situations and Contexts

What this assessment objective means

Using and applying knowledge and understanding, of processes, procedures, generalisations principles and theories to specified, concrete situations. AO2 is about being able to take the understanding of generalities (AO1b) and apply them to specific novel situations. It is more granular than the more extended synthesis/creation that may respond to an analysis (AO3a) of a more holistic complex situation/brief.

A candidate can

- differentiate relevant from irrelevant information in a given, new situation,
- select appropriate procedures/principles from memory and
- implement these procedures and principles appropriately for the given situation.

This is assessed within the examination by

Given a clear, straightforward/narrow situation, the question requires selection and application of relevant principles and procedures in a way that is specific to the situation (rather than in general terms).

- What is the best approach to… in this situation?
- Explain the process/ procedure to take when…
- What are the implications of …(specific rather than general situation).

6.1. Question and Mark Scheme

<table>
<tr><td rowspan="3">Q12)</td><td>Stem</td><td colspan="2">An engineering company has purchased a truck to deliver heavy goods to their clients throughout the UK. The truck will be used daily and will spend the majority of time on the road.

Explain why the value of the truck would depreciate over time.

(3 marks)</td></tr>
<tr><td colspan="2">Acceptable answer(s)</td><td>Marking guidance</td></tr>
<tr><td colspan="2">• Depreciation would be due to excessive mileage caused by continued use [1].
• Depreciation will be due to the wear and tear linked to the heavy goods it is transporting [1].
• Depreciation could also be impacted by damage due to higher risk of accidents due to the amount of time on the road [1].
• The truck would be less desirable/become obsolete over time as it ages [1].</td><td>Award 1 mark for each relevant point up to maximum of 3 marks.

Credit other suitable responses.</td></tr>
<tr><td>Total marks</td><td colspan="3">3</td></tr>
<tr><td>AO</td><td colspan="3">AO2 = 3</td></tr>
<tr><td>Qual spec reference</td><td colspan="3">15.2.3.3 - depreciation</td></tr>
</table>

6.2. Candidate Response

Example (3 marks)

The truck would depreciate over time because the model is getting older and newer models may be released (1) and it is going to have lots of miles put on it (1) as it will be used to transport heavy goods which will put stress on the truck, causing it to work harder (1).

Examiner Commentary on application of mark scheme

Mark 1: Aligns to the fourth point in the mark scheme about the truck becoming obsolete.

Mark 2: Aligns to the first point in the mark scheme relating to excessive mileage, which is inferred from the scenario given within the question.

Mark 3: Aligns to the second point in the mark scheme about the impact of the heavy goods, using information from the scenario set around the question.

Example (2 marks)

If the truck is constantly driving, parts will be worn down (1) and the heavy load will damage other parts (1) over time too due to fatigue.

Examiner Commentary on application of mark scheme

Mark 1: Aligns to point in the mark scheme around wear and tear along with constant use.

Mark 2: Is given under credit other suitable responses for recognising the stress the heavy load may additionally put on the vehicle.

Example (1 marks)

The value of the truck would depreciate over time by adding more miles onto the truck (1) to decrease the values as it has a lot of miles on the car from being driven all over the UK.

Examiner Commentary on application of mark scheme

Mark 1: aligns to the first point in the mark scheme relating to excessive mileage, the candidate goes on to repeat this point again, hence not achieving any further marks.

6.3. Examiner Hints and Tips

- Any context given to the candidates is needed to answer the question in full. It is crucial candidates acknowledge this context in their response and tailor their knowledge to this context.
- Candidate should be encouraged to highlight or underline the context given within the question. They should consider how this context impacts on the question they are being asked. They will only be given context and information which is relevant and needed for them to answer the question.
- Candidate should link their responses against the question context and requirements specifically, trying not to respond randomly in their own words.

7. Section B – Extended Response and AO3 (Analysis and Evaluation)

AO3a Analysis
What this assessment objective means
Complex thinking that distinguishes patterns and relationships, breaking material into constituent parts, and determining how the parts are related to one another and holistically, inferring underlying assumptions / conditions / relevance / causation.
It can be seen an extension of understanding (AO1b), or a prelude to evaluation (AO3b) and to the creation of a response to, for example, a complex brief or situation (more fully assessed in the project).

A candidate can
- break down a complex problem into parts
- consider the relationships between the parts
- manipulate knowledge and experience to determine a range of solutions/proposals
- balance competing priorities to suggest the best outcome.

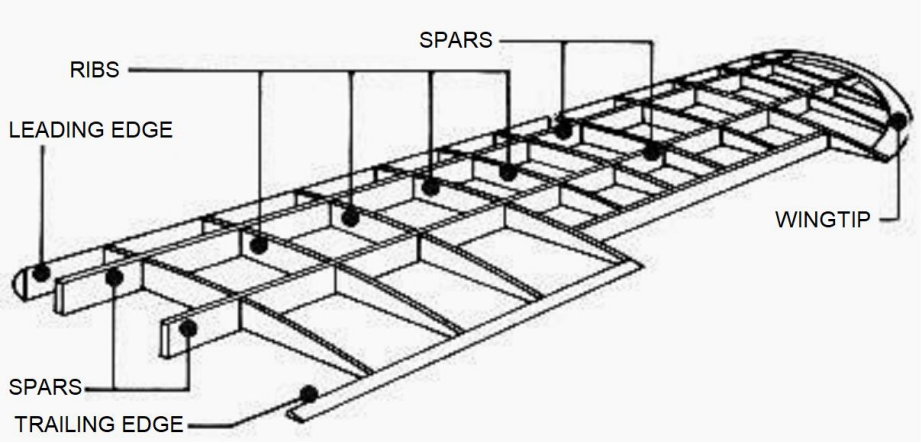
This is assessed within the examination by
Given a relatively complex, realistic occupationally relevant scenario, stating a situation that implies (but does not directly state) the need for application of a number of different (possibly competing) principles / approaches / procedures; a requirement to respond / propose solutions
- Analyse the situation recommending an approach to be taken to…
- Analyse how the situation can be managed in order to…
- Analyse the consequences of…

AO3b Evaluation
What this assessment objective means
Ability to make judgements about the value, for some purpose, of own or other's work / ideas / solutions / methods using internal or external criteria or standards relevant for the occupational area. These criteria may include eg quality, accuracy, effectiveness, efficiency, coherence, consistency, and may be quantitative or qualitative.

A candidate can
- judge the quality of actions proposals, outcomes
- using their own internal quality standards
- using external standards / criteria
- can justify their judgements of quality.

This is assessed within the examination by
Must have something either given or supplied by the candidate to be evaluated; often following / as part of analysis and the proposal of eg an approach, (AO3a above).
- …justify your decisions/approach
- Evaluate how well … meets …standards
- Evaluate how effective/efficient…

7.1. Question and Mark Scheme

Q 20	**Stem**	An engineer is designing the internal structure of an aircraft wing, like that shown in Figure 8. The aircraft will be a high performance, single passenger vehicle manufactured in small quantities.  **Figure 8** Wing Structure - Published anonymously-http://aeropioneer.blogspot.com Discuss the material properties that are **most** important when designing this internal structure. Recommend a suitable main material and justify your choice. (12 marks)

Marking Bands

For no awardable content, award 0 marks.

Band	Marks	Descriptor
1	1 – 3	Explains a few considerations for selecting the material. Demonstrates basic application of knowledge and understanding of materials and their properties. Demonstrates basic evaluative skills with limited reasoning to which material would be most suitable. A material is recommended which may not be fully appropriate. The response lacks some clarity and is generally poorly structured.
2	4 – 6	Demonstrates a good use of analysis of some considerations for selecting the material.

		Demonstrates good application of knowledge and understanding of materials suitable for the structure and their properties. Demonstrates good evaluative skills with clear reasoning to which material would be most suitable. The response is generally clearly expressed, with some consideration given to how it is structured.
3	7 – 9	Demonstrates thorough understanding of a wide variety of considerations for selecting the material. Demonstrates thorough application of knowledge and understanding of a variety of materials suitable for the structure and their properties. Demonstrates thorough evaluative skills with thorough reasoning and justifications to which material would be most suitable. The response is clearly expressed and is well-structured.
4	10 - 12	Demonstrates comprehensive understanding of a wide variety of considerations for selecting the material. Demonstrates comprehensive application of knowledge and understanding of a wide variety of materials suitable for the structure and their properties. Demonstrates comprehensive evaluative skills, comprehensive reasoning and justifications to which material would be most suitable. The response is fully coherent and is articulated using a logical structure that maximises understanding.

Indicative Content

Material Properties

- Physical properties – Density, corrosion resistance, weldability, ability to be recycled.
- Mechanical properties – Strength (tensile, compressive, shear, torsion), toughness, brittleness, ductility, elasticity, malleability.
    - The main consideration would be the performance requirements, such as weight, strength, rigidity etc.
    - Must be low density / lightweight to reduce fuel consumption and allow high speeds to be achieved.
    - Must have good stiffness indicated by its Young's modulus to ensure that the wing is rigid / does not flex as this could reduce aerodynamic performance.
    - Must have good strength to support the mass of the wing.
    - Must have good toughness to prevent failure in the event of collision with a bird.

- Must have good corrosion resistance as exposed to outdoor weather conditions.

Suitable main material and justification

- Suitable types of material would include composites, aluminium alloys, titanium alloys.
- Must be low cost, if possible, to maximise profit by the manufacturer or reduce cost to the customer.
- Form of available materials, such as fibre sheet, metal tubes, as appropriate to the material types, as this influences the required manufacturing processes, and hence the complexity of designs that can be achieved.
- The potential effects of processing on the material (including heat treatment and surface finish such as painting, if applicable).
- The existence of laws, regulations and standards for aerospace applications.

Total Marks	12
AO	AO2 = 4 AO3 = 8
Element	Synoptic
Test spec reference	5.6, 5.7, 6.1, 6.2, 6.3, 6.4, 6.5, 7.1

What do we mean by:

	AO2 Application	**AO3a** Analysis	**AO3b** Evaluation
Basic	Limited understanding that is relevant to the context or question. Limited accuracy in interpretation through lack of application of relevant knowledge and understanding.	Limited accuracy in analysis through lack of application of relevant knowledge and understanding.	Un-supported evaluation through lack of application of knowledge and understanding. Un-supported judgement through lack of application of knowledge and understanding.
Good	Some understanding that is relevant to the context or question. Some accuracy in interpretation through the application of some relevant knowledge and understanding.	Some accuracy in analysis through the application of some relevant knowledge and understanding.	Partially supported evaluation through the application of some relevant knowledge and understanding. Partially supported judgement through the application of some relevant knowledge and understanding.
Thorough	A range of accurate understanding that is relevant to the context or question. Accurate interpretation through the application of relevant knowledge and understanding.	Accurate analysis through the application of relevant knowledge and understanding.	Supported evaluation through the application of relevant knowledge and understanding. Supported judgement through the application of relevant knowledge and understanding.
Comprehensive	A range of detailed and accurate understanding that is fully relevant to the context or question. Detailed and accurate interpretation through the application of relevant knowledge and understanding.	Detailed and accurate analysis through the application of relevant knowledge and understanding.	Detailed and substantiated evaluation through the application of relevant knowledge and understanding. Detailed and substantiated judgement through the application of relevant knowledge and understanding.

7.2. Candidate Responses

7.2.1. Band 1

Top of band 1 response (3 marks)

The most important property is tensile strength this is because the ribs the spurs and the leading edge all give some support to the pannells. Also when the air craft is landing the nose is raised and a lot of force is exerted onto the wing of the plane if the wing is not strong enough then it may cause damage to the wing and could cause it to crash.

Another important property that needs to be considered is the weight. the internal structure must also be lightweight as it is being used in a high-performance single passenger vehicle.

Finally cost would be important, as the are high performance planes and are being produced in small quantities. This means that they could sell them at a high price and will not need to worry abut cost as much.

Examiner Commentary on application of mark scheme

This response was awarded three marks meaning it securely meets the Band 1 descriptor for this question. The commentary below explores how they have done this.

The candidate explores two considerations for selecting the material: tensile strength and weight. In the third paragraph the candidate considers cost, which is not a material property however would be a valid consideration when selecting a material.

Demonstrates basic application of knowledge and understanding of materials and their properties there is a basic understanding of tensile strength, and how the structure of the plane requires a material to support this. There is also applied considerations of the context of a plane, and the operating parameters.

The candidate has shown basic evaluative skills, and there is limited reasoning to support these. The candidate has failed to identify a suitable material to be used, and instead has focused generally on the properties to consider.

There was no conclusion provided by the candidate. In general, this response also lacked clarity, due to the structure and use of language.

7.2.2. Band 2

Top of band 2 response (6 marks)

The properties of the materials used in the plane wing include: lightweight, compressive strength, toughness, rust resistant, strong; The materials needs to be lightweight as it can't hold the plane down as when the plane is in the air it will cost more fuel to fly if the plane is heavier. The material needs to have compressive strength as when the plane is in the sky there will be lots of pressure on the wing from the air/wing. The material needs to be tough as the smallest scratch or indentation can change the aerodynamics of the plane causing the plane to not fly as well. The material must also be rust resistant as rust can change the strength and/or the performance of the plane. The material must also be strong as it needs to be able to hold its shape in harsh conditions. The material I would chose is Aluminium, because it is strong and is more lightweight compared to other materials such as steel and is a cheap material that doesn't rust easily.

Examiner Commentary on application of mark scheme

This response was awarded six marks meaning it securely meets the Band 2 descriptor for this question. The commentary below explores how they have done this.

The candidate considers several material properties (lightweight, compressive strength, tough, rust resistant and strong) and provides some good analysis as to why these properties are important when selecting a suitable material.

The candidate demonstrates a good application of knowledge by relating the material properties identified back to the context of the question (e.g. the structure of the plane). The candidate has identified a material and demonstrates some understanding by identifying that aluminium has some of the properties required. However, the candidate has failed to consider the use of aluminium alloys which would be a more suitable material.

The candidate has provided a partially supported evaluation by comparing aluminium to steel in relation to some of the material properties identified. The candidate's response could have evaluated the material selected against other materials (apart from steel) and provided more in depth reasoning.

The response is generally clearly expressed, with some consideration given to how it is structured. However, it would have benefitted from the use of paragraphs to structure the response.

7.2.3. Band 3

Top of band 3 (9 marks)

- *Lightweight. Flying the plane should weigh as little as possible to keep it airbourne. One of the necessary features is that it must be high performing so therefore weight is very important due to speed possibilities.*
- *Tough. Due to rapid pressure changes when taking of/landing, the wing material must be tough so it doesn't crack or break causing a possibly catastrophic failure while airbourne.*
- *Corrosion resistant. No reactive material should be used as the metal frame should not rust or corrode before it's next check.*

Possible materials:

- *Carbon fibre- very strong material so chances of breaking is very small. It is weather resistant aswell.*
  However carbon fibres is produced in sheets not blocks and would be very expensive even in small qualities. I don't think it is a very good or realistic material to be used.
- *Steel – using steel would be a lot cheaper than most other materials.*
  However steel isn't very corrosion/weather resistant, stainless steel is an option though. It is also quite heavy so the performance of the aircraft would be hindered significantly.
- *Aluminium – Reletively lightweight, weather proof and can be strengthened/hardaned by heat treatment. An Aluminium alloy – is lightweight and corrosion resistant and is stronger than pure aluminium.*
  Aluminium and aluminium alloy is more lightweight than steel and a lot cheaper than carbon fibre as well as having many possibilities for improving its properties.

In my opinion Aluminium alloy is the best choice as it is reletively cheap and easy to source, it is lightweight and corrosion resistant and should be strong enough overall.

Examiner Commentary on application of mark scheme

The candidate has demonstrated a thorough understanding of a wide variety of material properties (lightweight, tough, corrosion resistant, strength) needed when selecting a suitable material for an aircraft wing.

The candidate has analysed their choice of materials and demonstrated application of relevant knowledge and understanding by relating the materials identified back to the properties needed for the structure of an aircraft wing.

Within the candidate's response, they have demonstrated evaluative skills with clear reasoning to which material would be most suitable, comparing one material to another along with justifications. The candidate has also considered that aluminium alloy may be a more suitable material due to its properties.

The response is clearly expressed and is well-structured. The candidate has split their answer into two distinct paragraphs, initially exploring the material properties and then exploring a variety of materials, and finally given a summary paragraph.

7.2.4. Band 4

Top of band 4 (12 marks)

The most important properties are:

- *It should be lightweight. The material should be low density so the wing doesn't weigh much. The lighter the wing is, the easier it is for the plane to fly, the faster it can go and less fuel is needed to make the plane fly.*
- *It should be strong so it doesn't' bend or brake and can support the weight of the plane when its flying.*
- *It should be tough so it doesn't crack or brake when it hits something like a bird when its flying.*
- *It should be corrosion resistent, so it doesn't rust when it goes through rain or clouds or snow.*
- *It should be low cost as this will keep the cost of the plane down so it will be cheaper for people to travel.*
- *It should be easy to manufacture the shapes needed, as this keeps the cost down.*

Materials that could be considered are carbon fiber composite (CRP), steel, aluminum or titanium. The ones with the lowest density are crp and aluminum and titanium, which all have a better strength to weight ratio than steel. Steel would be cheeper than any of these, but is much heavier. Steel would also rust, so would need to be painted. Aluminum and titanium are corrosion resistent so would not rust and wouldn't need painting which would cost more money. CRP would not rust but sometimes can swell when wet which is like a form of corrosion and could make the wing deform.

Titanium costs more than aluminum but both are less than CRP. All these three can have high strength and are tough, but aluminum and titanium has more ductility than CRP so would be better if something hit a wing as they would bend rather than braking. All the metals can be cast and machined and are easy to get hold of. CRP would have to be made in the shape needed as it cant be machined, so would give less waste but there are lots of different parts needed so there would need to be a lot of different moulds made so the cost to make the wing parts would be high.

In conclusion, in comparison to the other materials, aluminum would be the best choice due to its combination of low density, corrosion resistence, good strength and toughness, relative cost and being easy to make the parts from.

When I'm writing aluminum and titanium it means aluminum and titanium alloys, not the pure metals which aren't as strong.

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Examiner Commentary on application of mark scheme

The candidate has demonstrated a comprehensive understanding of a wide range of considerations (exploring both physical and mechanical properties) when selecting a suitable material for the aircraft wing.

The candidate's response demonstrated an accurate understanding of a wide range of materials (both suitable – CRP, aluminium alloys and titanium alloys - and unsuitable materials - steel) and provided an analysis of their properties in relation to the context of an aircraft wing. The response was detailed and accurate, applying relevant knowledge and understanding and fully relating back to the context of the question.

The candidate demonstrated a comprehensive evaluation by comparing the materials and provided accurate reasoning and justifications as to why these materials would (or would not) be suitable in relation to their properties and the context of the question. The candidate identified a suitable material (aluminium alloy) and provided substantiated judgement for its use.

The response is fully coherent and is articulated in the main using a logical structure (such as the use of paragraphs) that supported understanding.

7.3. Examiner Hints and Tips

- These questions are designed to differentiate candidate's performance, they assess higher order thinking skills and as such they do stretch and challenge candidates.
- It's key that candidates give themselves sufficient time to respond to these lengthier questions.
- Although these questions appear in Section B, candidates can choose to tackle the extended response questions first before returning to Section A if they are concerned about their time management.
- Before writing out in full their answer to extended questions, candidates may find it helpful to identify the key requirements of the question and jot down a brief plan or outline of how they will answer it. This will help clarify their thinking and make sure that they don't get 'bogged down' or provide too much detail for one part of the question at the expense of others.
- By planning candidates can ensure they provide a structure to their response and that they have covered off the major points they wish to make in their response. By considering the structure of the response, and how one point may link to another they will be able to demonstrate both their ability to analyse and evaluate sufficiently to access the higher mark bands.
- Candidates will not receive more marks if they make the same point multiple times.
- Candidates need to ensure their answers balance the ability to demonstrate a breadth of knowledge i.e. making multiple points, against ensuring they demonstrate their depth of understanding on the subject matter. If candidates recall lots of points but fail to demonstrate the ability to evaluate and analyse these points, they will be marked into the lower bands. Likewise, if they only explore one point in extensive detail, they will not demonstrate they have sufficient breadth of knowledge of the subject area and will not be able to access higher bands.
- Candidates should be encouraged to write in continuous prose. A bullet point list will demonstrate some knowledge, but it will not demonstrate to the examiner that the candidate is able to analyse or evaluate, therefore limiting them to the bottom of the lowest band.
- When making a point in response to the question the candidate needs to explain why they think this point is relevant to the question, this demonstrates their ability to make judgements and is therefore evidence of evaluation.
- Similarly, to the Application questions, candidates will be given context within the question and it's key that their answers are tailored to the context/situation given. Its key they give examples which support the context given.

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