T Level Technical Qualification in Engineering and Manufacturing

Engineering and Manufacturing Core

Theory Exam 2 - Engineering in Context

Mark Scheme

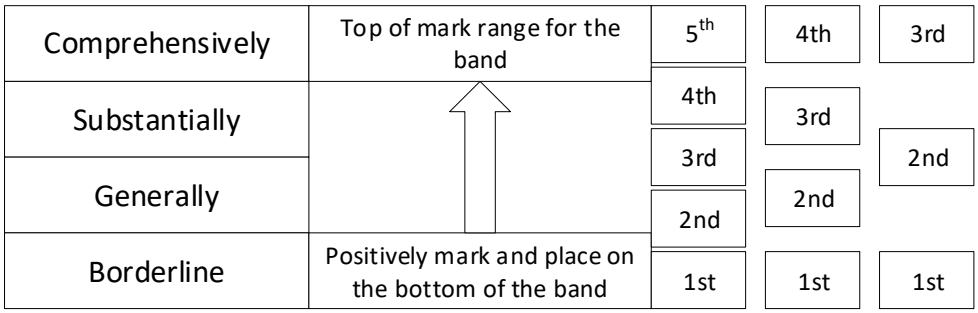
Marker guidance

Unless otherwise stated in the marker guidance for a specific question, the following conventions apply:

- all marking, from start to finish must be consistent and in line with the mark scheme guidance. Continue to refer to the mark scheme throughout marking
- for questions that ask for a specific number of points, accept the first answers given up to the number requested e.g. State three… only accept the first three answers listed, and disregard any additional answers provided
- for questions requiring continuous prose answers, mark positively – all correct answers should receive the appropriate mark according to the mark scheme. Any wrong (**but neutral**) answers should be ignored, and no marks should be lost
- in some circumstances, it is appropriate to disallow a candidate answer that initially appears to give the correct answer as given in the mark scheme, if it is undermined by the fact that it goes on to actively **contradict** its intention. Sometimes the minimal wording used in the mark scheme allows a match that in reality is trivial and it is clear the candidate is referring to the wrong knowledge/understanding. Only the part of the response to which the contradiction applies should be disallowed, not the whole response. Material that is irrelevant/neutral but not contradictory should be ignored and positive marking applied as above
- use the full range marks for a question as described by the mark scheme – e.g. for a 2 mark question, 0, 1 or 2 marks will always be available to award (never just 0 or 2). For levels marking, the full range of marks should be used freely as described by the mark scheme including 0 and full marks
- always award whole marks; half marks cannot be awarded
- allow phonetic misspellings as long as the meaning is clear, i.e. not so similar to another relevant but wrong term that you have to guess which was intended
- only allow 'it' as reference to the question topic if it is clear what 'it' refers to
- mark crossed out work UNLESS it has been replaced by another response
- where judgement is required, apply the guidance. Where the guidance does not sufficiently support for a particular candidate response/interpretation, contact your Team Lead
- accept alternative wording that reflects that given in the mark scheme
- contact your Team Lead if any additional correct answers arise which need to be added to the mark scheme
- for level of response mark schemes:

  Note: indicative content has been provided to help orient the marking, providing a sense of the intentions of the question and expected parameters of the response. It is not exhaustive, and candidates do not need to cover all points referenced. Candidates may provide good quality responses while taking an approach which legitimately focuses either on breadth or depth given the time constraints. While the best responses are more likely to go to some depth across a broader range, there will be acceptable variation. Any pointers in the question towards coverage eg '…a range of…' should be kept in mind and balanced, though professional judgement, as to how much this affects the overall quality of the response when applying the marking instructions.

  - First, read the full candidate response and decide which band descriptor best fits the overall level of quality of the response, in the context of the indicative content.
  - Then, to decide on a mark within the band, consider the ***degree to which*** **the response fits the criteria**, as indicated by the diagram below:



The table below provides further detail on the descriptors used within each of the mark bands and what is expected at each level. Use the descriptors below alongside the mark scheme to support accurate and consistent judgment of candidate's response and allocation of marks.

AO2	**AO3**
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. Unsupported 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.

This exam has been split into **two** sections.

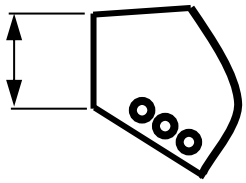
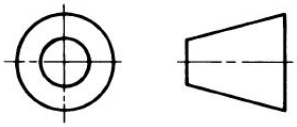
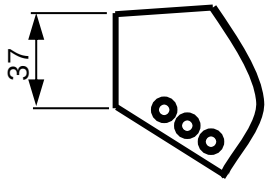
Below details the types of questions and marks available for each section. Please allow time for each section accordingly.

Section A is made up of **67** marks and includes **11** short answer and medium answer questions.
Section B is made up of **33** marks and includes **3** extended response questions.

Assessment Objectives	Mark allocation
AO1a Demonstrate knowledge The ability to demonstrate basic recall of relevant knowledge in response to straightforward questioning e.g. material properties.	**10%**
AO1b Demonstrate understanding The ability to explain principles and concepts beyond recall of definitions, but in a general way – i.e. out of a particular context in response to straight forward questioning e.g. simple concepts and terms of description in engineering contexts.	**22%**
AO2 Apply knowledge and understanding to different situations and contexts Using and applying knowledge and understanding, taking the understanding of generalities and applying them to specific situations. Questions are likely to ask for application in relation to a straightforward situation – e.g. assessing the application of a single concept and the application of essential mathematical concepts.	**46%**
AO3 Analyse or evaluate information & issues The ability to analyse the interrelated issues arising from a complex scenario and to evaluate these to propose a best solution or predict impacts etc e.g. – evaluating materials properties and requirements for engineered products.	**22%**

Section A

Q1	A company manufactures and assembles gear boxes. Identify **two** methods to reduce human error that could occur during production. (2 marks)	
Mark Scheme	• Employer to provide appropriate training [1]. • Frequent breaks during shifts [1]. • Sufficient rest allowed between shifts [1]. • Adequate staffing to prevent overworking employees [1]. • Workload planning [1]. • Standard working hours [1]. • Flexibility in working patterns [1]. • Employee support [1]. • Clear communication between management and staff [1]. • Management of expectations [1].	**Marking guidance** Award 1 mark per method, up to a maximum of 2 marks. Credit other suitable methods.
Total marks	2	
AO	AO1a = 2	
Qual spec reference	14.3.3 – human error	

Q2 a)	Figure 1 shows one view of a component in a product. The dimension of the indicated feature is 37 mm. Using the standard conventions for an orthographic drawing, write this value in the correct location on Figure 1. (1 mark)  Figure 1
Q2 b)	What does the symbol in Figure 2 represent on an orthographic drawing? (1 mark)  Figure 2
Q2 c)	What does this type of line represent on an orthographic drawing? (1 mark)
Q2 d)	What does the abbreviation AF mean on an orthographic drawing? (1 mark)
Q2 e)	What does the geometric dimensioning and tolerancing (GDT) symbol in Figure 3 mean? (1 mark)  Figure 3
Mark Scheme	(a) 1 mark for the placement of the dimension to the left of the dimension line and equidistant between the arrows – as shown on the Figure below [1]  (b) Third angle projection [1]. (c) Centre line [1]. (d) Across Flats [1]. (e) Perpendicularity [1].
Total marks	5
AO	AO1a = 5
Qual spec reference	a - 3.1.2.4.5 - dimension b - 3.1.2.9.1 - projection symbols c - 3.1.2.8.2 - centre line CL d - 3.1.2.8.1 - across flats AF e - 3.2.4.3 - perpendicularity

Q3	When managing risks in a manufacturing environment, a hierarchy of control is used. The first step in the hierarchy is elimination of risk. State the other **four** steps in order of the hierarchy. (1 mark)	
Mark Scheme	• Reduction/substitution • Engineering controls to isolate risk • Changing in working methods / administrative controls / training / safe system of work • Personal protective equipment (PPE)	**Marking guidance** 1 mark for all four steps presented in the correct order. Do not accept any other alternative responses.
Total marks	1	
AO	AO1a = 1	
Qual spec reference	12.4.1 – stages of risk assessment	

Q4	Explain the purpose of a wiring diagram. (2 marks)	
Mark Scheme	To show how electrical components / cables are arranged / connected [1] which allows the physical layout to be clearly displayed [1].	**Marking guidance** 1 mark for the purpose, with a second mark for the supporting explanation, up to a maximum of 2 marks.
Total marks	2	
AO	AO1b = 2	
Qual spec reference	3.1.1.9.1 – wiring diagrams	

Q5	A company manufactures parts for car engines on a production line.	
Q5 a)	Explain **two** reasons why the company may use condition-based monitoring rather than preventative maintenance for the machines on the production line. (4 marks)	
Mark Scheme	• Maintaining output of the production line / continuity of production / performance standards / reduced risk of unplanned downtime [1] due to premature failure of parts between service intervals [1]. • Reduced cost of parts / saving the company money [1] as parts are only replaced when necessary rather than at fixed intervals [1]. • Increased reliability / efficiency of equipment / quality standard of components [1] due to reduced deterioration in machine performance [1].	**Marking guidance** 1 mark for a reason, with a second mark for the supporting explanation, up to a maximum of 4 marks. Credit other suitable responses
Total marks	4	
AO	AO1b = 4	
Qual spec reference	1.2.1.4 – condition-based monitoring	

Q5 b)	State **two** legal responsibilities for health and safety that apply to the employees operating the machining processes on the production line. (2 marks)	
Mark Scheme	• Behave and work safely so as not to harm self or anyone on the production line [1]. • Not to attempt any work unless sufficiently trained and authorised to do so [1]. • Not to interfere with safety devices put in place such as removing machine guards [1]. • Wear appropriate PPE [1]. • Follow workplace practices such as safe working policies [1].	**Marking guidance** 1 mark per correct legal responsibility up to a maximum of 2 marks.
Total marks	2	
AO	AO1a = 2	
Qual spec reference	12.3.2 – employee and employer obligations	

Q5 c)	The company currently inspects every machined part to ensure that it meets the requirements. Explain **two** ways in which changing from 100% inspection of every machined part to statistical process control could affect the company. (4 marks)	
Mark Scheme	• Statistical Process Control takes less time and money to carry out [1]; this could increase the profitability of the production for the company [1]. • SPC could allow for immediate process adjustments to identified issues by operators [1]; this would result in fewer parts being produced and scrapped for faults reducing the cost per machine part [1]. • There is a statistical risk that defects would not be detected without 100% inspection compounding quality issues through the manufacturing stages [1]; this could result in reputational damage and reduce sales where quality is important [1].	**Marking guidance** 1 mark per way and 1 further mark per linked explanation, up to a maximum of 4 marks. Credit other suitable responses
Total marks	4	
AO	AO1b = 4	
Qual spec reference	11.1.2.8 – statistical process control (SPC)	

Q5 d)	During an inspection, the company found crack defects in the manufactured parts. Explain how a cause and effect diagram could be used when investigating this defect. (3 marks)	
Mark Scheme	It provides a visual representation of all possible causes of the problem [1] which means that the root cause of the cracking can be identified [1], by allowing the causal relationships between different potential causes to be considered separately from the overall process [1].	**Marking guidance** Award one mark per relevant point, up to a maximum of 3 marks. Credit other suitable responses
Total marks	3	
AO	AO1b = 3	
Qual spec reference	11.1.3.3 – cause and effect diagrams	

Q6	Explain **one** advantage of using a kanban system for managing work in progress to a company that carries out batch manufacturing. (2 marks)	
Mark Scheme	• Kanban would reduce the amount of work in progress between machines [1], which would reduce the amount of cash tied up in work in progress [1]. • Out of specification parts could be identified after a smaller quantity of parts has been produced [1], allowing earlier intervention, reducing scrap / net total rework requirements [1].	**Marking guidance** 1 mark per advantage and 1 further mark for a linked explanation, up to a maximum of 2 marks. Credit other suitable responses
Total marks	2	
AO	AO1b = 2	
Qual spec reference	16.1.2.7 – kanban	

Q7	Give **three** ways in which continuous professional development (CPD) can motivate employees of an engineering company. (3 marks)	
Mark Scheme	• It enables employees to gain relevant skills on the job / keep qualifications and skills up to date [1]. • Provides new skills which would assist employees with career progression [1]. • Enables employees to adapt to changing demands, reducing stress levels [1]. • Widens the skillset of employees, leading to increased job satisfaction [1]. • Provides goal and target setting opportunities for employees [1]. • Demonstrates that the company is taking employees' needs into consideration [1].	**Marking guidance** Award 1 mark per way given, up to a maximum of 3 marks. Credit other suitable methods.
Total marks	3	
AO	AO1b = 3	
Qual spec reference	14.2 – Continuous professional development (CPD) and professional recognition	

Q8	A multinational company is planning a project to develop a new product. The design will be developed at three sites: the ideas generation and engineering drawings for the project will be carried out by teams in the UK and India; prototype testing will be carried out in the USA.	
Q8 a)	Explain **one** benefit and **one** limitation of collaborative working for the design activity. (4 marks)	
Mark Scheme	**Benefits:** • Producing the ideas, engineering drawings and carrying out testing in different time zones gives the possibility of 'round the clock' working [1] which will allow the products to be developed in a much shorter timescale [1]. • The multiple sites in the design phase facilitates the contribution of different skills and/or experience of collaborators [1], reducing design fixation/increasing the potential creativity of the products [1]. • Potential cost reduction for the project [1], as a result of collaboration with teams in lower cost economies [1]. **Limitations:** • Differences in the languages spoken at the different sites /cultural differences / different standards or units of measurement applied in different regions could lead to misunderstandings/miscommunication [1] meaning that the product in progress does not match the intentions of the initial designers [1]. • Design security/confidentiality could be compromised [1] due to misdirected communication between sites / the large number of people involved [1].	**Marking guidance** 1 mark for one benefit and 1 mark for one limitation, and 1 further mark for the supporting reasoning or detail of each, up to a maximum of 4 marks. Credit other suitable responses
Total marks	4	
AO	AO2 = 4	
Qual spec reference	17.1.7 – collaborative working	

Q8 b)	The manufacturing of the components will be carried out at different sites in China and Europe. An engineer at this company has been asked to produce a project plan, running from the start of the design activity up to the commercial availability of the product. Explain why critical path analysis (CPA) would be used for the planning of this project. (3 marks)	
Mark Scheme	• The site receiving the components will be prepared to make progress without delay [1], because CPA would make it clear when there is a transition in activities between the sites carrying out the work [1], which would allow the advance organisation of transportation [1]. • Reduction of the timescale to completion [1] due to activities such as ideas generation, design, analysis, engineering drawing, manufacture, assembly and testing running concurrently / with an overlap and simultaneous parts manufacture at two different sites [1], which will consequently reduce the cost of production [1].	**Marking guidance** Award one mark per relevant point of explanation, up to a maximum of 3 marks. Credit other suitable responses.
Total marks	3	
AO	AO2 = 3	
Qual spec reference	17.3.1.3 – critical path analysis (CPA)	

Q9	A pressure vessel is used for manufacturing chemicals. It has a single access hatch. The vessel is 1 metre in diameter. A modification is required to the interior of the vessel, which is classed as a confined space. Explain **two** health and safety considerations required to carry out this activity. (4 marks)	
Mark Scheme	• Breathing apparatus may be required [1] due to the limited supply of oxygen in confined spaces which would lead to asphyxiation hazards [1]. • Lock out tag out (LOTO) would be required [1] to ensure that the vessel is not in use during the activity, as there a high risk of fatality due to the pressure in the vessel [1]. • Permit to work required [1] to ensure that staff carrying out the activity are appropriately trained in working in confined spaces are [1]. • Use of a buddy system to intervene [1] if monitored oxygen levels have diminished / there are physical signs of oxygen deprivation [1].	**Marking guidance** 1 mark per consideration and 1 further mark for a linked explanation, up to a maximum of 4 marks. Credit other suitable responses.
Total marks	4	
AO	AO2 = 4	
Qual spec reference	12.5.1 – considerations [for health and safety]	

Q10

An engineer wants to start up a company to assemble and sell a machine that allows organisations to recycle paper products on-site to make usable paper.

The company needs to:

- raise finance
- purchase appropriate premises with a limited budget
- source components
- build a good reputation.

Q10 a) Discuss the use of shares as a source of finance for this company. (6 marks)

Levels of response

Band	Marks	Descriptor
3	**5-6**	Demonstrates correct and specific application of thorough knowledge and clear understanding of shares and other sources of finance, to the specific situation in the question. Thorough discussion of a variety of advantages and limitations of shares for this company.
2	**3-4**	Demonstrates good application of knowledge and understanding of shares and other sources of finance, to the specific situation in the question. Discussion of some advantages and limitations of shares for this company.
1	**1-2**	Demonstrates limited application of knowledge and understanding of shares, and mostly describes the characteristics of shares. Basic discussion of a few advantages and/or limitations of shares for this company.
	0	**No relevant material**

Indicative content

- A new start-up by an individual would find it difficult to obtain other sources of finance such as savings, a direct entrepreneurial investment or a loan.
- Shares could be used to raise the full amount, but they may also not be sufficient for the full amount or require commission or dealing fees to be paid.
- Other forms of financing, such as government start up loans, would not meet the full amount of investment required.
- Shares spread the financial risk between shareholders rather than placing it with one individual and are therefore lower risk than other options.
- Using shares could be a preferable option for the engineer, as they would otherwise have to use their own financial assets.
- Shares could be lower cost than loans, as there would be no interest to pay, however there might be dividends payable.
- Shares may incur greater administrative costs to provide information and meetings with shareholders, which could be an additional cost to the start-up company.
- Shareholders are personally invested in the company and therefore more likely to promote the company and its products.
- Shareholders being personally invested can lead to more customers and raise the company's profile and reputation.
- Shareholders may require influence over the direction and activities of the company, which may be different to the views of the founding engineer.

Total marks	6
AO	AO2 = 6
Qual spec reference	13.3.3 – sources of finance

Q10 b)	The machine is assembled from 50 parts, each of which is bought from different suppliers. It is anticipated that 100 machines must be delivered each month to meet customer requirements. The company plans to use Just In Time (JIT) as their inventory management system. Explain **two** advantages of adopting the Just In Time approach for the company. (4 marks)	
Mark Scheme	• With JIT the number of parts stored would only be a few hundred at a time rather than 5000 [1], which would minimise the amount of money tied up in inventory [1]. • Space requirements for storing components used per month are reduced [1], allowing the company to buy smaller and cheaper premises for assembly and dispatch [1].	**Marking guidance** 1 mark for each advantage and 1 further mark for a linked explanation, up to a maximum of 4 marks. Credit other suitable responses.
Total marks	4	
AO	AO2 = 4	
Qual spec reference	15.1.2.1 – just in time	

Q10 c)	Explain **two** benefits to this engineering company of implementing ISO 14001. (4 marks)	
Mark Scheme	• ISO can be an effective environmental management system to help increase efficiencies [1] which would reduce the cost of materials used [1]. • The implemented changes resulting from ISO 14001 could reduce the cost of waste removal [1] and therefore increase profitability [1]. • Manage environmental obligations with consistency [1], which provides assurance to regulatory bodies that the environmental impact is being managed [1]. • Since the product is related to sustainability, implementing the standard would improve their reputation with their target customers [1] therefore supporting sales / increasing brand loyalty [1].	**Marking guidance** Award 1 mark for a benefit and 1 further mark for a linked explanation, up to a maximum of 4 marks. Credit other suitable responses.
Total marks	4	
AO	AO1b = 4	
Qual spec reference	12.6.2.1 – ISO 14001	

Q11	A company designs and manufactures robot arms to package eggs.	
Q11 a)	The factory that manufactures the parts of the robot arm has a variety of manually controlled wasting and joining processes. The arms are assembled by human workers. Explain **one** way in which 'design for manufacture and assembly' may have influenced the design of the robot arm. (2 marks)	
Mark Scheme	• As only wasting and joining processes are available, the design must be made from commercially available forms of material [1] which means that it cannot include features specific to alternative manufacturing processes [1]. • As the processes are manually controlled, this may limit the tolerances that can be achieved [1], and therefore the ability to reproduce identical parts [1]. • The design may include bevelled edges / tapers of appropriate size [1] to facilitate manual assembly of the parts by the human workers [1]. • Designs should avoid symmetrical features where possible / use asymmetrical features [1] to reduce the probability of errors during assembly [1].	**Marking guidance** 1 mark for each potential influence, with a second mark each for the supporting explanation, up to a maximum of 2 marks. Credit other suitable responses.
Total marks	2	
AO	AO2 = 2	
Qual spec reference	1.1.4 – approaches to design	

Q11 b)	The gripper on the robot arm picks up eggs individually from a conveyor belt. The robot arm moves and places the eggs in boxes on a separate conveyor belt. Sensors ensure that the eggs are not broken and are placed in the correct position. Explain **three** benefits of using a closed loop system to control the robot arm in this application. (6 marks)	
Mark Scheme	• If a feedback sensor does not detect an egg in the gripper, the operation could be modified [1], preventing unnecessary operations / wasted time [1]. • The pressure exerted on the egg could be monitored using an appropriate feedback sensor (e.g. QTC) [1], preventing breakages / mess due to excess pressure or reduction in pressure resulting in the egg being dropped [1]. • The movement of the robot arm could be monitored using a proximity sensor [1] to ensure accuracy in positioning of the egg in the box [1].	**Marking guidance** 1 mark per applied benefit of a closed loop system and a further mark for the linked explanation. Credit other suitable responses.
Total marks	6	
AO	AO2 = 6	
Qual spec reference	10.1.1.6 – open and closed loop systems	

Q11 c)	The processes in the factory are organised in a functional arrangement. Parts are moved between processes on pallets using forklift trucks. At least one day's work is queued at each process, so they do not stop production. Explain, using examples, how the company could use value stream mapping to improve the performance of their manufacturing activity. (6 marks)

<table>
<tr><td>Levels of response</td><td>
<table>
<tr><th>Band</th><th>Marks</th><th>Descriptor</th></tr>
<tr><td>3</td><td>5-6</td><td>Demonstrates correct and specific application of thorough knowledge and clear understanding of value stream mapping (VSM) to the specific situation in the question.
Thoroughly explores a range of ways in which VSM would improve the performance of this company.</td></tr>
<tr><td>2</td><td>3-4</td><td>Demonstrates good application of knowledge and understanding of VSM to the specific situation in the question.
Explores one way thoroughly or a range of ways in limited depth, in which VSM would improve the performance of this company.</td></tr>
<tr><td>1</td><td>1-2</td><td>Demonstrates limited application of knowledge and understanding of VSM, and mostly describes VSM as a concept.
Superficially explores one or two ways in which VSM is used by companies more generally.</td></tr>
<tr><td></td><td>0</td><td>No relevant material</td></tr>
</table>
Indicative content
• The actual flow of products within a company can develop substantially over time and not follow the optimal efficiency.
• VSM will map the actual route of the process flow, which may be different to their common understanding and perception.
• Different types of activity will be represented by symbols on the map.
• The process of creating the map will involve physically following the flow of materials through the company.
• Each activity would be categorised as value-added or non-value-added.
• Non-value-added activities would be reduced.
  ○ Non-value-added activities could include the transportation between processes by the forklifts due to the functional arrangement of the processes. This could be addressed by minimising the distances between processes and reducing the labour required to carry out this activity.
  ○ Quantities of stored materials or work in progress would be reduced, which decreases the net cash flow required for operation.
  ○ Reducing the amount of quality defects that arise reduces the amount of machining operations that do not add value and scrap costs.
• This information would be used to increase the proportion of value-added activities, such as machining operations.
• For example, moving to a product-oriented arrangement of the processes would lead to reduced waiting time due to lower inventory.
</td></tr>
<tr><td>Total marks</td><td>6</td></tr>
<tr><td>AO</td><td>AO2 = 6</td></tr>
<tr><td>Qual spec reference</td><td>16.1.2.1 – value stream mapping</td></tr>
</table>

Section B

<table>
<tr><td>Q12</td><td>Analyse how the internal combustion engine has contributed to the social and economic development of the UK. (9 marks)</td></tr>
<tr><td>Mark Scheme</td><td>
<table>
<tr><th>Band</th><th>Marks</th><th>Descriptor</th></tr>
<tr><td>3</td><td>7-9</td><td>Demonstrates comprehensive application of knowledge and understanding in relation to how the internal combustion engine has contributed to social and economic development.
Demonstrates comprehensive analysis of a wide range of contributions of the internal combustion engine to the social and economic development of the UK.
Demonstrates a thorough evaluation, comprehensive reasoning and considerations of different points.</td></tr>
<tr><td>2</td><td>4-6</td><td>Evidence of good application of knowledge and understanding in relation how the internal combustion engine has contributed to social and economic development.
Demonstrates a good analysis of a range of contributions of the internal combustion engine to the social and economic development of the UK.
Good evaluation providing some good considerations of different points.</td></tr>
<tr><td>1</td><td>1-3</td><td>Evidence of basic application of knowledge and understanding that is partially relevant to how the internal combustion engine has contributed to social and economic development.
Demonstrates a basic analysis of a limited range of contributions of the internal combustion engine to the social and economic development of the UK.
Some basic evaluation which partially considers different factors and contributions, with limited links between the development of the internal combustion engine and the social and economic development of the UK.</td></tr>
<tr><td></td><td>0</td><td>No relevant material</td></tr>
</table>
Indicative content

• The development of the internal combustion engine led to increased ease of transportation for a wide range of goods and perishable items. Access to these items stimulated demand from potential customers resulting in economic growth generally as the market for these items increased, and broader regional economic growth as money flowed between the expanding customer base and the supplying areas.
• The increased ease of travel facilitated greater geographic mobility for people and allowed workers to live farther from their place of employment. This had an influence on the cost and distribution of housing, distributing economic growth by increasing costs some distances from employment and accordingly reducing demand directly adjacent to the places of employment.
• The ease of travel also allowed people to travel more for leisure, which boosted the travelling and hospitality sector.
• Increased travelling has allowed exposure to a wider range of different cultures, leading social progress and increased diversity.
</td></tr>
</table>

	• The internal combustion engine led to the development of the automotive and petrochemical industries and their supply chains, which provided employment opportunities increasing the affluence of the workforce (and with increased spending power, economic growth as above). • Fuel production also benefited the national economy through taxation, which has been used to support other areas of economic activity (such as benefits and healthcare for workers). • The increased use of internal combustion engines has been associated with adverse effects of air quality and has resulted in health implications, which in turn has increased demand of healthcare providers and increased associated healthcare costs.
Total marks	9
AO	AO2 = 3 AO3 = 6
Qual spec reference	2.2.3 – the internal combustion engine Synoptic

Q13

Evaluate how emerging trends in augmented reality (AR) could change engineering and manufacturing activities in the following sectors:

- design
- maintenance
- manufacturing.

(12 marks)

Mark Scheme

Band	Marks	Descriptor
4	**10-12**	Demonstrates detailed understanding of what is meant by AR across a variety of specific engineering applications, in specific design, manufacture and maintenance activities. Explains a wide variety of direct and indirect influences of AR on a wide range of specific engineering activities across all three sectors, with comprehensive supporting understanding of the reasons for implementation. The potential impact of AR in a variety of engineering applications is evaluated in detail and conclusions made, fully supported by analysis of the requirements of the applications and the potential benefits. The response is fully coherent and is articulated using a logical structure that maximises understanding.
3	**7-9**	Demonstrates understanding of what is meant by AR in a range of specific engineering applications, in design, manufacture and maintenance activities. Explains a range of direct potential influences of AR on specific engineering activities across all three sectors, with supporting understanding of the reasons for implementation. The potential impact of AR in a range of specific engineering applications is evaluated, with some supporting analysis of the application requirements or benefits. The response is clearly expressed and is well-structured.
2	**4-6**	Demonstrates understanding of what is meant by AR in at least two of the sectors of design, maintenance or manufacture. Explains some direct potential influences of AR on a few specific engineering activities, potentially in two of the engineering sectors. Some comments evaluating the potential impact of AR related to some applications in engineering, with some supporting explanation. The response is generally clearly expressed, with some consideration given to how it is structured.
1	**1-3**	Demonstrates understanding of what is meant by AR in a general context and describes a few potential applications of AR, potentially in only one of the sectors listed. Explains a few potential influences of AR on a limited range of engineering activities, potentially in only one of the sectors. A few general comments are made evaluating the potential impact of AR on engineering. The response lacks some clarity and is generally poorly structured.
	0	**No relevant material**

	Responses that only offer an evaluation of one of the sectors listed should be limited to band 1; an evaluation of two of the sectors listed should be limited to band 2; an evaluation of all three of the sectors listed would be in bands 3 or 4. **Indicative content** **Design** • AR will be able to layer aspects of the design – visuals, sounds, environmental movements, in real-time, leading to more efficient and thoughtful development with less wasteful experimentation of materials. • AR could be used to get customer feedback on designs at an early stage and allow the user to experience created products, reducing the risk in investment decisions. • Immersive AR environments such as holorooms could allow designers to test and evaluate innovative product designs without the expense of making physical prototypes, reducing development costs for innovative products. • AR gives the ability to superimpose the design concept on the produced prototype or product to identify any differences. • AR does raise some concerns about data security and sharing information, so may increase the need for cyber security. **Maintenance** • Could provide instructions/standard operating procedures for activities in progress. • Could identify parts during a maintenance activity that need to be removed or replaced. • AR could facilitate access to settings for gauges and operating limits, which reduces the time taken for the activity. • AR could allow for assessment of unsafe situations to evaluate corrective and preventative maintenance activities. • AR could cause distractions whilst undertaking maintenance activities, which could result in increased risk of accidents. **Manufacturing** • AR could be used to measure the dimensions of observed components and compare these to the requirements. • AR could provide standard operating procedures for loading and unloading machines. • AR could give access to machine parameters and settings, which reduces the need for technical knowledge required to carry out the task. • Could facilitate access to CAD drawings without access to hard copy engineering drawings. • The cost of AR technology could exceed the value it adds, especially when manufacturing products in smaller quantities.
Total marks	12
AO	AO2 = 4 AO3 = 8
Qual spec reference	2.3 - Synoptic

Q14

The UK has committed to achieving a net-zero greenhouse emissions target through a range of policy changes, in order to create a more sustainable society.

Discuss how environmental considerations affect the design, manufacture and maintenance activities in the engineering industry. (12 marks)

Mark Scheme

Band	Marks	Descriptor
4	**10-12**	Demonstrates detailed understanding of a variety of environmental considerations that relate to the design, manufacture and maintenance activities. Explains how a wide variety of identified environmental considerations directly and indirectly affect a range of engineering activities, with comprehensive supporting understanding of its implications. The potential impact of these environmental considerations in a variety of engineering applications is discussed in detail and conclusions made, fully supported by analysis of the requirements of the applications and the potential benefits. The response is fully coherent and is articulated using a logical structure that maximises understanding.
3	**7-9**	Demonstrates understanding of a range of environmental considerations that relate to the design, manufacture and maintenance activities. Explains how a range of identified environmental considerations directly affect specific engineering activities across all three sectors, with supporting understanding of their implications. The potential impact of these environmental considerations on all three sectors is discussed, with some supporting analysis of the application requirements or benefits. The response is clearly expressed and is well-structured.
2	**4-6**	Demonstrates understanding of a few environmental considerations that that relate to potentially two of the engineering sectors. Explains how some of the identified environmental considerations directly affect some engineering activities in at least two of the sectors. Some comments discussing the potential impact of these environmental considerations on at least two sectors with some supporting explanation. The response is generally clearly expressed, with some consideration given to how it is structured.
1	**1-3**	Demonstrates understanding of what is meant by environmental considerations in a general context and describes a few environmental considerations that affect only one of the sectors listed. Explains how a few of the identified environmental considerations affect the specific activities in potentially only one of the sectors listed. A few general comments are made discussing the impact of these environmental considerations in engineering. The response lacks some clarity and is generally poorly structured.
	0	**No relevant material**

	Indicative content **Design** • Environmental considerations during the development of new products, including use of the 6Rs (reduce, refuse, rethink, repair, reuse, recycle), sustainable design and the circular economy. • Requirements of environmental regulations and standards and how these will change designs as they are updated, such as reducing the use of banned and restricted substances. • The impact of different stakeholders on the implementation of responses to environmental issues. • Design using high quality materials and components, in order to decrease failure rates of products. **Manufacture** • Impact of power sources and renewables in the creation of products, such as reducing the use of fossil fuels and increasing the use of sustainable energy sources. • Increased use of automation technologies using renewable power sources, examples of innovative technologies, such as hybrid technologies. • Increased use of smart technologies to monitor energy usage and adapt behaviours during product manufacture. • Techniques that reduce waste of materials during manufacturing, such as nesting, and safe and ecological disposal of waste. **Maintenance** • Increased use of planned and scheduled maintenance techniques, which leads to extended machine life and therefore reduced demand for raw materials for new parts. • Maintenance helps to prevent localised pollution issues, such as oil leaks, through replacing or repairing damaged filters, pipework or fittings. • Repairing components and parts where possible rather than replacing with new parts, to extend obsolescence. • Methods of safe reuse, recycling and disposal of parts.
Total marks	12
AO	AO2 = 4 AO3 = 8
Qual spec reference	12.6 Synoptic

The T Level is a qualification approved and managed by the Institute for Apprenticeships and Technical Education.