OCR
Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

A Level in Design and Technology: Design Engineering

H404/01 Principles of Design Engineering

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 80

This document consists of 28 pages

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:
   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks
   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)
   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. **Annotations**

Annotation	Meaning
BP	Blank page
✔	Point where mark is awarded
✘	Incorrect response
L1	Level one response
L2	Level two response
L3	Level three response
ECF	Error carried forward
BOD	Benefit of doubt accepted
REP	Repetition
SEEN	Noted, but no credit given
PD	Poor diagram offering unclear response

11. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

The breakdown of Assessment Objectives for A Level in Design & Technology

	Assessment Objective
AO3	**Analyse and evaluate –** • **design decisions and outcomes, including for prototypes made by themselves and others** • **wider issues in design and technology**
AO3.1a	Analyse design decisions and outcomes, including for prototypes made by themselves and others
AO3.1b	Evaluate design decisions and outcomes, including for prototypes made by themselves and others
AO3.2a	Analyse wider issues in design and technology
AO3.2b	Evaluate wider issues in design and technology
AO4	**Demonstrate and apply knowledge and understanding of –** • **technical principles** • **design and making principles**
AO4.1a	Demonstrate knowledge of technical principles
AO4.1b	Demonstrate understanding of technical principles
AO4.1c	Apply knowledge and understanding of technical principles
AO4.2a	Demonstrate knowledge of design and making principles
AO4.2b	Demonstrate understanding of design and making principles
AO4.2c	Apply knowledge and understanding of design and making principles

Question			Answer	Marks	Guidance
1	(a)		Reasons why designers are now developing bicycles to be foldable, e.g.: More people now buy them to take on a train (✓), because of the introduction of congestion/parking charges if they use their cars. (✓) Other possible points include: • the increased scale of production of folding bicycles has reduced the manufacturing costs, which makes the bikes more affordable and within the budgets of more users • improved CAD and the use of modern materials has made folding bikes more rideable, more functional, lighter etc., so they are safer, faster and more enjoyable to ride • folding bikes are becoming fashionable, thanks to media coverage of celebrities using them and users like the image they portray. **Award credit for any other appropriate response**	**2** **AO4 2c**	1 mark for identifying a reason why designers are now developing bicycles to be foldable. 1 mark for explaining the reason given. Specific reference to design decisions in relation to the foldable bicycles is needed for the marks. Responses that relate to reducing space should not be awarded.
1	(b)		Explanation of ergonomic features of the bicycle, e.g.: There is an adjustable seating position, (✓) so that the bike can be appropriately set up safely for any rider (✓) There is a luggage rack over the rear wheel (✓) so that the user can carry a bag during the journey which keeps their hands/body free from obstruction, ensuring a safer and easier ride. (✓) Other possible ergonomic points include: • mud guards over both wheels, to prevent mud and spray dirtying the user's professional clothes when	**4** **AO3 2 x 1a** **AO4 2 x 2c**	1 mark for each of two identified ergonomic features from analysing the bicycle in **Fig.1**. 1 mark for explaining these ergonomic features. Candidates can draw on experience from product analysis to support their response to this question. Examples should only be given against what can actually be seen, not just assumed from looking at **Fig 1**. Specific reference to ergonomic features in relation to the folding bicycle in **Fig.1** is needed for the marks.

Question			Answer	Marks	Guidance
			riding to work • when folded, the bike can be carried by placing one hand under the saddle, so it is easy to move around, leaving one hand free to open doors etc. **Award credit for any other appropriate response**		

Question			Answer	Marks	Guidance
1	(c)	(i)	Working properties of aluminium alloy used for the frame, e.g.: Aluminium alloy has a high strength to weight ratio (✓), so that the frame is strong to withstand road use but not too heavy to affect the bike's portability. (✓) Aluminium alloy can be welded (✓) which enables the components parts of the frame to be strongly and securely joined during manufacturing. (✓) Other possible properties include: • Aluminium alloy is available in the correct stock form (tube sections), so that it can simply be cut to length during fabrication • Aluminium alloy can take a suitable paint finish, so that the bike's aesthetics/branding can be achieved • Aluminium alloy is resistant to water corrosion so that, if the paint is scratched, the frame material will not rust when exposed to rain and road dirt. **Award credit for any other appropriate response**	**4** **AO4 1c**	1 mark for identifying a suitable working property of aluminium alloy that makes it suitable for the bicycle. 1 mark for explaining why the property makes aluminium alloy suitable. Specific reference to the working properties of aluminium alloy in relation to its suitability for the frame of the folding bicycle is needed for the marks. Do **not** award marks for inappropriate isolated properties (e.g. flexible) if it isn't clear how they relate to the bike frame.
1	(c)	(ii)	Mass = volume × density (✓) (4 079 × 2.78) = 11 339 + 3 467 = 14.81kg (✓) **Award marks for alternative methods of calculation**	**2** **AO4 1c**	1 mark for recall of correct formula. 1 mark for substituting into the formula and calculating mass of a bicycle. **Correct answer scores full marks.**

Question			Answer	Marks	Guidance
1	(d)		Pressure = $\frac{force}{area}$ (✓) Pressure = $\frac{148 \div 2}{500}$ = 0.148 = 0.15 N/mm^2 (✓) **Award credit for any other appropriate method of calculation**	**2** **AO4 1 x 1a** **AO4 1 x 1c**	1 mark for recalling pressure formula. 1 mark for assuming the even distribution of weight on each tyre, substituting into formula and calculating the pressure each tyre exerts on the ground.
1	(e)		Circumference of wheel = πd Circumference = π × 0.406 = 1.28m (✓) Wheel revolutions per second = $\frac{speed\ (ms{-}1)}{circumference}$ Rev/s = $\frac{7.8}{1.28*}$ = 6.12 rev/s (✓) Gear ratio = speed of front sprocket / speed of rear sprocket = no. of teeth on rear sprocket / no. of teeth on front sprocket = $\frac{1.3}{6.12*}$ = 0.21 (✓) Front sprocket teeth = $\frac{rear\ sprocket\ teeth}{gear\ ratio}$ Front sprocket teeth = $\frac{11}{0.21*}$ = 51.7 = 52 (✓) **Award credit for any other appropriate method of calculation**	**4** **AO4 1c**	1 mark for calculating the circumference of the bike wheel, based on the understanding that one rotation of the rear wheel the bike will move it forward the distance that is equal to its circumference. 1 mark for calculating rear wheel rotational speed based on the understanding of speed equals distance moved in a given time. 1 mark for calculating the gear ratio through an understanding that relative rotational speeds of the front and rear sprockets is related to the ratio of teeth on each sprocket. 1 mark for calculating the number of teeth following on from the previous understanding of number of teeth related to speed. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks**

Question			Answer	Marks	Guidance	
					Content	Levels of response
1	(f)		Indicative Content: • Concern for the excessive use of raw materials might encourage the manufacturer to reduce the quantity of materials by using thinner tube walls and a less elastic material to compensate. The use of fully or partly recycled materials would also reduce the impact of using raw materials. • Pollution created during manufacture could be a concern – pollution can be created by processing of raw materials and by processes during fabrication and assembly of the bike, e.g. fumes from welding, fumes from spray paint etc. • The excessive use of energy during manufacture can be a concern, because of the fuel wasted and the inevitable pollution created. Processes using high energy levels include welding, heating frames to cure the paint, and the heating/lighting costs of factories. • Poor planning can lead to excessive waste materials being generated. This might be offcuts from a tubular stock length which have no use so end up being discarded, or poor stock control which leaves too many materials and components left over at the end of the batch. • For the waste that is inevitably generated, concern about how this might be disposed of. This might include small of amounts of paints or adhesives which would normally simply be thrown away. • Concern for the carbon footprint created by transporting materials and parts over long distances, and then distributing the products out to the retailers. Manufacturers and consumers may be keen to buy a bike which has been manufactured locally to reduce this impact on the environment.	**8** **AO3 2 x 2a** **AO3 2 x 2b** **AO4 2 x 2a** **AO4 2 x 2b**	All responses must be in relation to how concern for the environment might impact on the manufacture of a folding bicycle. Candidate operating at Level 3 should be accessing all AO4(2a/2b) marks, at least half of the AO3(1a/1b) marks. Candidate operating at Level 2 will be accessing at least half of the AO4 (1a/2a) marks, at least one of the AO3 (2a/2b) marks. Candidate operating at Level 1 will only access AO4(2a/2b) marks.	**Level 3 (6–8 marks)** The candidate produces a thorough discussion of the concern for the environmental might impact on the manufacturing of a folding bicycle. The candidate shows a mature understanding and evaluates the wider issues in the question through the use of examples and their discussion is more cohesive and well-considered as a result. **Level 2 (3–5 marks)** The candidate produces a sound discussion of the concern for the environmental might impact on the manufacturing of a folding bicycle. The candidate shows a reasonable understanding and evaluates the wider issues in the question through the use of examples and their discussion is in the most part cohesive and well-considered. **Level 1 (1–2 marks)** The candidate demonstrates basic knowledge of the concern for the environmental

Question			Answer	Marks	Guidance	
			• The manufacture of a folding bike can have an effect on the environment. Therefore, environmental concern can impact on manufacture in a variety of ways: i. the use of raw materials ii. the disposal of waste iii. surplus materials iv. by-products of production v. use of energy **Award credit for any other appropriate response**			might impact on the manufacturing of a folding bicycle. Any understanding is limited with little consideration of wider issues. There is no analysis or evaluation. **Level 0 (0 marks)** No response or no response worthy of credit.

Question			Answer	Marks	Guidance
2	**(a)**		Advantages of using AGV's during a production process, e.g.: An AGV is able to operate 24/7 without the need for breaks. (✓) An AGV provides flexibility as its operation can be easily reprogrammed and it can be deployed elsewhere on production line. (✓) Other possible advantages include: • AGVs can replace dangerous tasks (e.g. carrying explosive materials) previously performed by humans • they can reduce labour costs in the long run as less staff will be required to move stock • AGVs eliminate human error. **Award credit for any other appropriate response**	**2** **AO4 1c**	1 mark for each of two identified advantages of using AGVs during a production process. Specific reference to the use of AGVs in relation to a production process is needed for the marks. **Do not accept** "reduce costs" alone without qualification of what costs in particular is reduced.

Question			Answer	Marks	Guidance
2	(b)	(i)	Minimum angle = $\frac{360}{24}$ = 15° (✓) **Award credit for any other appropriate method of calculation**	**1** **AO4 1c**	1 mark for demonstrating understanding that the minimum rotation angle that can be detected is the angle in a full circle ÷ the number of holes in the encoder disk. **Correct answer scores full marks.** **Do not allow the answer 7.5°** (which will be obtained if candidates think that it is acceptable to detect the edge of each slot, as the accepted resolution of this type of sensor depends only on the **number** of slots).
2	(b)	(ii)	the period = 40ms (✓) S = d ÷ t, S = $\frac{1}{24}$ ÷ 40* = 1.04 rev s^{-1} (✓) **Award credit for any other appropriate method of calculation**	**2** **AO3 1 x 2a** **AO4 1 x 1c**	1 mark for analysing the graph to identify the period. 1 mark for calculating speed using standard formula. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks**

Question			Answer	Marks	Guidance
2	(b)	(iii)	V = IR, R = $\frac{V}{I}$ (✓) R = 3 ÷ (50 × 10^{-6}) = 60kΩ (✓) **Award credit for any other appropriate method of calculation**	**2** **AO4 1 x 1a** **AO4 1 x 1c**	1 mark for identifying that Ohm's law is required, recalling and rearranging the formula V=IR. 1 mark for substituting in voltage and current to calculate the resistance. **Correct answer scores full marks** **Award** mark if result is expressed as 60 000Ω, or 60k.
2	(c)	(i)	Cosine rule $a^2 = b^2 + c^2 – 2bc\,CosA$ (✓) $1.8^2 = 2.2^2 + 1.6^2 – (2 × 2.2 × 1.6 × CosA)$ (✓) CosA = 4.16 ÷ (2 × 2.2 × 1.6) A = 53.8° (✓) **Award credit for any other appropriate method of calculation**	**3** **AO4 1c**	1 mark for recalling the cosine rule. 1 mark for substituting values in to the formula correctly. 1 mark for calculating angle A. **Correct answer scores full marks**

Question			Answer	Marks	Guidance
2	(c)	(ii)	Angle turned = 12 : 1= 12 × 53.8***** = 645.3° (✓) Number of revs = 645.3* ÷ 360 = 1.79 (✓) Stepper A pulses = 1.79* × 200 = 359 steps (✓) Pulse frequency = number of steps ÷ time = 359* ÷ 2 = 179 Hz(✓) **Award credit for any other appropriate response**	**4** **AO4 1c**	***ECF from Angle A calculated in 2c(i)** 1 mark for calculating the total angle turned by the stepper motor using the gearbox ratio. 1 mark for converting the angle turned by the stepper motor A into revolutions. 1 mark for calculating the number of steps required for stepper motor A. 1 mark for calculating the pulse frequency. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks.**

Question			Answer	Marks	Guidance
2	(c)	(iii)	Description of an open-loop control system and how it operates in relation to use in the robotic arm, e.g.: An open-loop control system means that there is no feedback between the output and the input. (✓) The arm moves according to the number of pulses sent to the stepper motors – the system does not check to see if the arm is in the correct position after moving. (✓) Other valid points linking to the robot arm include: • the arm moves by dead-reckoning, moving a known distance/angle for every pulse to the stepper motors • if the stepper motors in the robotic arm skip a pulse (e.g. if they are overloaded) then the arm will be out of correct position. **Award credit for any other appropriate response**	**2** **AO4 1 x 1a** **AO4 1 x 1c**	1 mark for describing an open-loop control system. 1 mark for how an open-loop control system operates in relation to the robotic arm. Specific reference to open-loop systems in relation to the robotic arm is needed for the full marks.
2	(c)	(iv)	Why the datum needs to be reset and how this position is received, e.g.: A datum is a known position and all the arm movements are made from this point, as there is no positional feedback. (✓) The arm moves continuously in one direction until it reaches a position sensor – at this point the datum is reached and the position is accurately known. (✓) **Award credit for any other appropriate response**	**2** **AO4 1c**	1 mark for explaining why the robotic arm needs to be reset to a datum. 1 mark for explaining how the reset position of the datum is achieved. Specific reference to the use a datum point in relation to functionality of the robotic arm is needed for the marks.

Question			Answer	Marks	Guidance
3	(a)		Why the design of electronic products is subject to registered trademarks and copyright, e.g.: Implementation of specific standards for a particular application, such as those published by ISO, ensure that an electronic product will have a wider user base (✓). This occurs because technical barriers are lifted, allowing different international groups to work together to achieve a mutually compatible outcome. (✓) International standards allow the designer to develop a communication product which will be compatible with systems worldwide. (✓) For example, international radio frequency standards ensure that a mobile phone will operate in countries throughout the world because they all agree on which frequency bands are in use. (✓) Other possible responses include: • Standardised parts are available worldwide which allows designers to incorporate interchangeable or replaceable parts into the designs (e.g. fasteners, batteries, light bulbs etc.), which enables repairs or upgrades to be carried out locally. • Compatibility with international communication protocols widens the product's application and ensures its place in the market as an add-on or expansion to existing systems that users already own. Examples of communication protocols include IP, USB, Bluetooth, MP3, PDF etc. • Adopting international standards for manufacturing (e.g. screw threads, material stock sizes, preferred values of electronic components etc.) allows a global approach to manufacturing, including contracting-out sub-manufacturing tasks, and buying-in components. This flexibility allows manufacturers to implement the most	**4** **AO4** **2 x 2a** **AO4** **2 x 2b**	1 mark for identifying each of two ways that the implementation of international standards impacts on the design of electronic products. 1 mark for explaining the given impact in relation to the design of electronic products. Candidates can draw on practical experience from their own undertaking of iterative design processes to support their response to this question.

Question			Answer	Marks	Guidance
			cost-effecting manufacturing strategy with the confidence that all aspects will be compatible with each other. • Standardised product labeling ensures consumer safety and promotes ergonomic aspects, lifting language barriers and cultural differences. Examples include the use of standardised safety symbols to give warnings, instructions, or to prohibit use. Standard logos such as 'play, pause, stop, rewind' etc. are recognised internationally and remove the need for the manufacturer to produce different versions of the product for sale in different countries. **Award credit for any other appropriate response**		

Question			Answer	Marks	Guidance	
					Content	Levels of response
3	(b)		Indicative content: • Products can be designed so that parts which commonly fail can be easily replaced. Such parts might include batteries or touchscreens. The use of standard parts helps achieve this, as does making the spare parts readily available on the open market. • Providing a service/maintenance schedule so that the product is regularly maintained and kept working to a high standard. Servicing can spot problems early on and correct these cheaply before the problem develops into a full product failure.	**8** **AO3 2 x 2a** **AO3 2 x 2b** **AO4 2 x 2a** **AO4 2 x 2b**	As a guide for full marks there will be two or three different examples or products discussed. Any examples must demonstrate how extension of their usable life has been considered in their design, purchase and supply methods. Candidates can draw on practical experience from their own undertaking of iterative design processes to support their response to this question. Candidate operating at Level 3 should be accessing all AO4(2a/2b) marks, at least half of the AO3 (2a/2b) marks.	**Level 3 (6–8 marks)** Candidate produces a thorough discussion of how considerations regarding the design, purchase and supply of products can extend their usable lives. Candidate shows a mature understanding and analysis of the wider issues in the question using appropriate and well-considered examples to inform their response. This creates a discussion that is both cohesive and well-considered. There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant

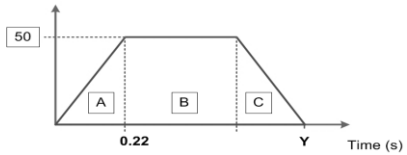
Question			Answer		Marks	Guidance
			• Providing freely available service manuals so that independent repairers can tackle the problem and not just franchised dealers. • Designing the product so that standard tools and diagnostic equipment can be used to trace faults and fix them. • Using higher quality components which are less likely to failure prematurely, and designing the product so that the components are working well within their rating and not being stressed. • Offering products on a leasing basis where the product continues to be owned by the manufacturer therefore there is an interest to design the product differently. • Providing facility for regular software updates to fix known issues and to keep the product in line with the features available on the latest models. The same applies to hardware updates, e.g. new cases, better cameras etc. • By adopting economic models for profit based on usage rather than one-off sale, manufacturers will focus their efforts on customers keeping and using the product, rather than replacing it, e.g. monthly subscription charges which include servicing and upgrades.		Candidate operating at Level 2 will be accessing at least half of the AO4 (2a/2b) marks and at least one of the AO3 (2a/2b) marks. Candidate operating at Level 1 will only access the AO4 (2a/2b) marks.	and substantiated with the use of examples. **Level 2 (3–5 marks)** Candidate produces a sound discussion of how considerations regarding the design, purchase and supply of products can extend their usable lives. Candidate shows a reasonable understanding and analysis of the wider issues in the question using adequate and for the most part well-considered examples to inform their response. This creates a discussion that is for the most part well-considered. There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence. **Level 1 (1–2 marks)** Candidate demonstrates a basic knowledge of how considerations regarding the design, purchase and supply of products can extend their usable lives. Any understanding is limited with little consideration of wider issues. There is no analysis or evaluation. The information has some relevance and is presented with

Question			Answer			Marks	Guidance
			Award credit for any other appropriate response				limited structure or detail The information is supported by limited evidence. **Level 0 (0 marks)** No response or no response worthy of credit.

Question			Answer	Marks	Guidance
4	**(a)**	**(i)**	How a suitable contactless technology enables data to be read from the ticket, e.g.: A RFID (radio frequency identification) process (✓) works when a microchip inside the ticket receives power by electromagnetic induction from a radio frequency field generated by the reader unit, and it responds by sending a unique identifier code by radio back to the reader unit. (✓) Other possible responses include: • Near Field Communication (NFC) which is similar to RFID in which data is transferred through a short range (4cm) radio field. NFC tickets can be passive (they receive energy from the radio field) or active such as a mobile phone running a payment app. • Integrated Circuit Card or IC e-card – similar to RFID but these cards are self-powered and rechargeable. • Barcode ticket – every ticket contains a unique identifier code printed as a barcode and this is read by an optical laser scanner when the ticket is held over the scanner window. • Quick Response Code or QR Code – similar to a	**2** **AO4** **1 x 1c**	1 mark for identifying a contactless technology suitable for controlling access to a public transport system. 1 mark for describing how this contactless technology enables data to be read from the ticket. Specific reference to contactless technology in relation to a ticket reader for a public transport access system is needed for the marks. Do **not** accept “smart phone” or “contactless phone”. Do **not** accept branded responses alone, e.g. Apple Pay, Oyster Card, m-Tickets, Chip and Pin or any other brands using contactless technology.

Question			Answer	Marks	Guidance
			barcode but in 2D allowing much more data to be stored and then transferred during the scanning process. **Award credit for any other appropriate response**		
4	**(a)**	**(ii)**	Why bearings would be used in the mechanical gate system, e.g.: They will reduce the friction within joint / system (✓) therefore the motion of the gates will be smoother, and more uniform. (✓) The use of bearings results in less energy being required to move the mechanical parts (✓), which reduces the overall power consumption and, therefore, the running costs of the mechanical gates. (✓) Other reasons may include: • Using bearings in the rotating parts of the mechanical gates reduces the torque required to overcome frictional losses and increases the mechanical efficiency of the system. • Using bearings on the main support shaft of the gates also provides radial support against a traveller pushing against the gates in a hurry to get through the turnstile. • Reducing static friction in the mechanical gate system enables the gates to start moving quicker meaning they can open/close rapidly, allowing more travellers through in a given time. • Bearings reduce wear between mechanical parts, increasing the longevity / life of the mechanical gate system, as it is likely to be in constant use. • Reducing friction will also reduce the noise created as the gates operate, which will improve the working	**4** **AO4 1c**	1 mark for identifying each of two reasons why bearings are used in mechanical gate systems. 1 mark for an explanation for why the reasons given are a suitable usage of bearings in mechanical gate systems. Specific reference to contactless technology in relation to a ticket reader for a public transport access system is needed for the marks.

Question			Answer	Marks	Guidance
			environment for people in the vicinity. **Award credit for any other appropriate response**		
4	**(a)**	**(iii)**	Implication of the improper use of lubrication on mechanical systems, e.g.: Under use or non-use of lubrication increases temperature of joint / system (✓) resulting in fusion / welding of components. (✓) Other responses could include: • Increases wear and tear of joint / system resulting in quickened fatigue and failure of joint / system. • Other examples may include: • Escapes intended joint / system causing issues and damaging others system, e.g. electronics. • Causes slippage of joint / system leading to inefficient performance of joint / system. • Difficult for future maintenance causing increases to maintenance costs and maintenance time required. **Award credit for any other appropriate response**	**2** **AO4** **1 x 1a** **AO4** **1 x 1b**	1 mark for identifying an implication of improper use of lubrication on mechanical systems. 1 mark for explaining the given implication in relation to mechanical systems.
4	**(b)**	**(i)**	Overall ratio = (60 ÷ 12) × (60 ÷ 10) × (60 ÷ 10) = 5 × 6 × 6 = 180 (:1) (✓) 45 ÷ 360 = 0.125 (or 1/8) revolutions (✓) Revolutions of motor = 180* × 0.125* = 22.5 (✓) **Award credit for any other appropriate method of calculation**	**3** **AO4** **1c**	1 mark for calculating the gear ratios for each compound stage. 1 mark for calculating the overall gear ratio. 1 mark for calculating the rotation of the turnstile gate through an opening cycle as a fraction of a complete cycle. 1 mark for calculating the number of revolutions for the motor to complete an opening cycle.

Question			Answer	Marks	Guidance
					*Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks**
4	**(b)**	**(ii)**	Gradient = $\frac{50}{X}$, X = $\frac{50}{\text{gradient}}$ = $\frac{50}{230}$ = 0.22 s (✓)  Section C = Section A = ½ X 0.22 × 50 = 5.5 rev (✓) 22.5 rev required, so Section B must be ABC – AC = 22.5 – (2 × 5.5) = 11 rev (✓) Length of B along the time axis = 11 / 50 = 0.22s (✓) Y = 0.22 + 0.22 + 0.22 = 0.66 s (✓)	**5** **AO3** **2 x 2a** **AO4** **3 x 1c**	1 mark for analysing the graph to identify the values for a gradient calculation and calculating the value of X. 1 mark for realising that the area within the graph represents the number of revolutions of the motor and calculating the area of the two triangular Sections A and C. 1 mark for calculating the area of the rectangular Section B. 1 mark calculating the length of the rectangular section along the time axis. 1 mark for calculating the value of Y. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks.**
4	**(b)**	**(iii)**	Why the motor speed is ramped down rather than maintained at full speed, e.g.: Slowing down the motor reduces the mechanical shock as the gate stops at the end of its travel (✓), which reduces wear on the system. (✓)	**2** **AO4** **1c**	1 mark for identifying a reason for ramping down the motor speed of the mechanical gate system in a controlled manner. 1 mark for a explaining why the designer would have chosen this course of action.

Question			Answer	Marks	Guidance
			Other possible reasons include: • To reduce the noise created as the gate hits the end stop, which would otherwise cause repeated annoyance throughout the day. • So that the entire movement is under control which improves safety for customers passing through the gate. **Award credit for any other appropriate response**		Specific reference to the ramping down of the motor speed in relation to the mechanical gate system is needed for the marks.

Question			Answer	Marks	Guidance	
					Content	Levels of response
4	(c)		**Indicative content** **Management** ISO9000 certification process to appreciate quality in house and from suppliers. BS 7850 as a standard for effective management of human resources and materials. Poke-Yokes as a simple checking strategy to eliminate errors arising for relative labour-intensive tasks. Implementation of Kaizen as a method of continuous improvement as workers are best placed to suggest improvements to processes and feel empowered and wanted within their jobs. **Quality Assurance** Check for quality raw materials / components from suppliers. Checking every stage of the manufacturing process. Induction / ongoing training for staff to ensure they understand how to achieve quality. Checking against the specification to ensure customer requirements.	**6** **AO3** **1 x 2a** **AO3** **1 x 2b** **AO4** **2 x 1a** **AO4** **2 x 1b**	As a guide for full marks the discussion should have at least one reference to management, quality assurance and quality control. If one section is missing in discussion, then full marks are not available. --- Candidate operating at Level 3 will access all of the AO4 (1a/1b) marks and at least one of the AO3 (2a/2b) marks. Candidate operating at Level 2 will access at least half of the AO4 (1a/1b) marks and at least one of the AO3 (2a/2b) marks. Candidate operating at Level 1 will only access the AO4 (1a/1b) marks.	**Level 3 (5–6 marks)** Candidate produces a thorough discussion of the features of TQM. Candidate shows a mature understanding to effectively discuss how TQM improves quality within manufacturing. The discussion is cohesive and well-considered. **Level 2 (3–4 marks)** Candidate produces a sound discussion of the features of TQM. Candidate shows a reasonable understanding that for the most part shows how TQM improves quality within manufacturing. The discussion is for the most part cohesive and well-considered. **Level 1 (1–2 marks)** Candidate demonstrates a basic knowledge of TQM. Any understanding of how TQM improves quality within manufacturing is limited. There is no analysis or evaluation. **Level 0 (0 marks)** No response or no response worthy of credit.

Question			Answer	Marks	Guidance	
					Content	Levels of response
			Quality Control Random Sampling of parts and components as they are being manufactured. Tolerances in place to ensure upper and lower dimensional allowances.			

Assessment Objectives (AO) grid

Question	AO3	AO4
1a		2
1b	2	2
1ci		4
1cii		2
1d		2
1e		4
1f	4	4
2a		2
2bi		1
2bii	1	1
2biii		2
2ci		3
2cii		4
2ciii		2
2civ		2
3a		4
3b	4	4
4ai		2
4aii		4
4aiii		2
4bi		3
4bii	2	3
4biii		2
4c	2	4
Total	15	65
Overall	80	

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