# Cambridge IGCSE™

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| **DESIGN & TECHNOLOGY** | **0445/43** |
| Paper 4 Systems and Control | **May/June 2021** |
| MARK SCHEME | |
| Maximum Mark: 50 | |

**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **13** printed pages.

**PUBLISHED**

**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

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| GENERIC MARKING PRINCIPLE 1:<br><br>Marks must be awarded in line with:<br><br>• the specific content of the mark scheme or the generic level descriptors for the question<br>• the specific skills defined in the mark scheme or in the generic level descriptors for the question<br>• the standard of response required by a candidate as exemplified by the standardisation scripts. |
| GENERIC MARKING PRINCIPLE 2:<br><br>Marks awarded are always **whole marks** (not half marks, or other fractions). |
| GENERIC MARKING PRINCIPLE 3:<br><br>Marks must be awarded **positively**:<br><br>• marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate<br>• marks are awarded when candidates clearly demonstrate what they know and can do<br>• marks are not deducted for errors<br>• marks are not deducted for omissions<br>• answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous. |
| GENERIC MARKING PRINCIPLE 4:<br><br>Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors. |

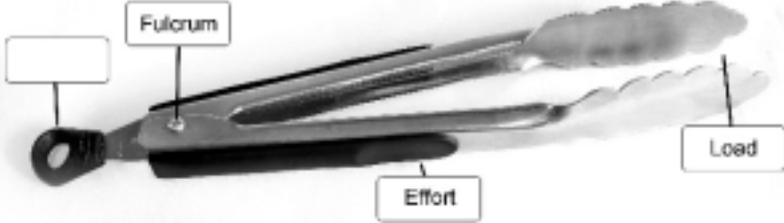| GENERIC MARKING PRINCIPLE 5: |
| :--- |
| Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen). |
| GENERIC MARKING PRINCIPLE 6: |
| Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind. |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1 | Properties that make the material suitable for a structure will include:<br><br>**Softwood**<br>• Plentiful supply<br>• Low cost<br>• Can be joined easily<br>• Renewable resource<br>• Resists tension, compression, bending and torsion<br><br>**Concrete**<br>• Strong in compression<br>• Can be strengthened in tension<br>• Low cost<br>• Long lasting<br>• Can be cast in situ<br><br>**Steel**<br>• Low cost<br>• High tensile strength<br>• Durable / long lasting<br>• Range of sizes / sections available<br>• Easily joined by temporary or permanent fastenings.<br><div align="right">3 × 1 mark</div> | 3 | Allow any valid alternatives<br><br><br><br><br><br><br><br><br><br><br><br><br><br>Allow –<br>Can be used to reinforce concrete.<br>Plentiful supply |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2 | Drawing / notes showing either a brace, tie or gusset plate that will keep the frame rigid<br>Suitable position / size, 1 mark<br>Suitable fixing method, 1 mark. | 2 | Allow 1 mark for a line drawing showing no width of brace/tie |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 3(a) | <br>1 mark for each correct. | 3 | No mark for any feature that is labelled twice, |
| 3(b) | • A third order lever is the only one that cannot give a mechanical advantage, [1]<br>• Effort is between the fulcrum and load, [1]<br>• Increases precision in use. [1]<br><br>2 × 1 mark | 2 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4(a) | Reasons for using materials will include:<br>**Brass**<br>• Will not corrode<br>• Good bearing qualities<br>• Teeth can be cut accurately<br><br>**Nylon**<br>• Low cost<br>• Can be injection moulded rather than cut<br>• No lubrication needed/low coefficient of friction<br>• Can be used as 'sacrificial' gear<br><br>**Steel**<br>• Hard wearing / durable<br>• Lower cost than brass<br>• Readily available<br><br>3 × 1 mark | 3 | Accept other valid reasons for choice.<br><br>Allow brass as self-lubricating.<br>Allow durable only if it is **not** used for steel.<br><br><br><br><br><br>Allow reference to the strength of steel. |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4(b) | Shear, 1 mark. | **1** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 5 | Ergonomic features could be:<br>• Handle shaped to fit hand<br>• Different material for grip<br>• Rounded surface with no sharp edges means comfortable grip<br>• Clear display, large numbers<br>• Buttons easily reached when holding<br>• Bar graph display as well as digital readout. | **2** | $2 \times 1$ mark for two features mentioned. Allow two marks for one feature fully described. |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6 | Purpose of a specification could be:<br>• To identify the features required in a design<br>• To provided instructions to a designer<br>• To measure initial ideas against<br>• When evaluating completed product. | **2** | Allow other valid uses of the specification. $2 \times 1$ mark for two purposes mentioned. Allow two marks for one purpose fully described. |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7 | Benefits will include<br>• Accuracy<br>• Repeatability<br>• Rapid production<br>• Quick change from one product to another<br>• Program can be modified easily<br>• Decrease in labour needed.<br><br>                                                     $2 \times 1$ mark | **2** | Allow other valid reasons |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8 | **A** is a battery / cell / power source<br>**B** is a switch<br>**C** is a motor<br><br>$3 \times 1$ mark | 3 | Accept any named type of switch for **B** |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 9 | • The switch will remain in new position after it has been actuated, 1 mark.<br>• Toggle action either makes or breaks the circuit, 1 mark<br>• Centre or common contact (C) is connected to either Normally open (NO) or Normally closed (NC) contact, 1 mark.<br><br>$2 \times 1$ mark | 2 | Accept **SPDT**<br>Accept inferred statement about switch not being momentary. |

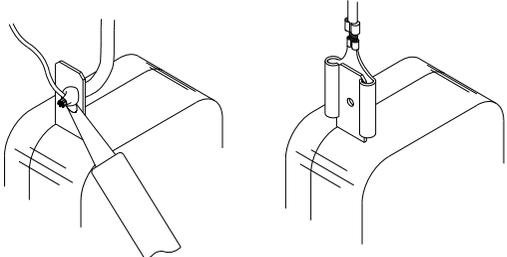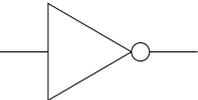| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 10(a)(i) | Stationary loads will include:<br>• Material used in the supporting structure<br>• Star<br>• Lighting on the star<br><br>Moving loads will include:<br>• Wind<br>• Snow / ice / rain<br>• Construction / maintenance workers on the structure<br><br>$2 \times 2$ marks | 4 | Allow other valid responses for either type of load. |
| 10(a)(ii) | A tie will resist tension, 1 mark<br>A strut will resist compression, bending and torsion, 1 mark | 2 | Allow a single resisted force for strut. |
| 10(a)(iii) | Advantage – a strut will resist different types of force, whereas a tie will only resist tension, 1 mark.<br>Disadvantage – increased weight in the structure as a result of using struts<br>The material for a strut is likely to be more expensive than a tie, 1 mark. | 2 | |

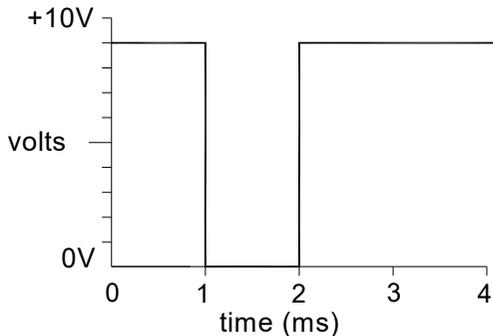| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 10(b)(i) | •    A single bolt will allow the joint to rotate<br>•    At least two bolts are needed to prevent this<br>•    To overcome failure of a single bolt<br>•    Three bolts are more likely to provide accurate alignment. | 2 | Two points mentioned for 2 marks.<br>Allow 2 marks for a single point fully explained. |
| 10(b)(ii) | Change in length is 0.1 mm,1 mark<br>Strain = 0.1 / 30 = **0.003**, 1 mark | 2 | Award both marks if correct answer is given with no evidence of working. |
| 10(b)(iii) | Torsion will cause the bolt to turn with the possibility of the bolt failing.<br>This will only occur if the bolt is over-tightened, in which case the head of the bolt will break away from the body.<br>Shear force will be applied to the threads on the bolt causing the threads to break away.<br><br>                                   $2 \times 2$ marks. | 4 | 1 mark for a single point recognised for each force. 2 marks if the response is justified. |
| 10(b)(iv) | Reasons for using bolts and nuts could include:<br>•    Possible need to disassemble the structure<br>•    Ease of transport to site<br>•    No chance of distortion of the materials<br>•    Different materials  / non-metals being joined<br>•    Three bolts will spread the load across full width of joint<br>•    Fine adjustments to position can be made before final tightening. | 2 | 2 marks for two points given in description.<br>Allow 2 marks for a single point fully justified. |
| 10(c)(i) | The span needed is greater than the length of timber available.<br>Access to position of beam may be limited, 1 mark for either point | 1 | |
| 10(c)(ii) | Advantages of method **B** include<br>•    No complex cutting and fitting of joint<br>•    Plates at side give lateral stability and increased strength<br>•    More bolts used that will spread the load. | 2 | Allow 2 marks for fully justified response.<br>Allow 1 mark for a single mentioned<br>Allow reference to comparative strength of the joints |
| 10(c)(iii) | Sketch to show at least three layers of 'beam width' laminates, 1 mark<br>Joints at ends of laminate staggered, 1 mark | 2 | |

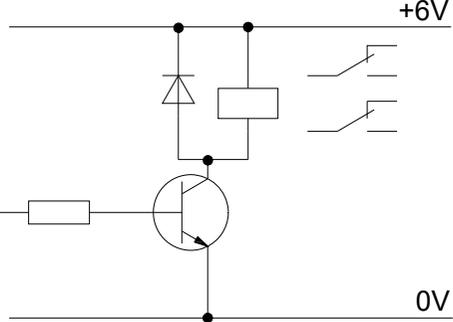| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 10(d) | • The purpose of the see-saw is to allow two users to rise and fall<br>• The movement of users means that it is not in equilibrium<br>• Different weights of user may mean that it is in equilibrium at the extent of its travel.<br>• Hard rubber spring will generate movement | 2 | Recognition that it is the users who cause movement and loss of equilibrium, 1 mark. Recognition of effect of imbalance in weight of users, 1 mark. |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(a)(i) | Drawing of a cam with dwell clearly shown, 1 mark<br>Label to indicate position of dwell, 1 mark. | 2 | |
| 11(a)(ii) | • The follower will rise four times, 1 mark<br>• The follower will fall four times, 1 mark<br>• The rise and fall are the same distance each time, 1 mark<br>• Mention of reciprocating motion, 1 mark<br>• There is no dwell, 1 mark.<br><div align="right">$2 \times 1$ marks</div> | 2 | Any two points included for 2 marks. |
| 11(a)(iii) | • The roller can follow the complete profile of the cam<br>• Roller follower will reduce friction between cam and follower<br>• A flat ended follower may bridge each of the lowest points<br><div align="right">1 mark for suitable benefit.</div> | 1 | Allow any other valid response |
| 11(b)(i) | Explanation should include:<br>• It is a one-way mechanism<br>• Pawl will drop into place through gravity or spring action<br>• The pawl prevents reverse movement of the ratchet. | 3 | Two points mentioned for 2 marks.<br>Allow 2 marks for a single point fully explained.<br>No mark for 'can apply tension'. |
| 11(b)(ii) | • Suitable size of tool / length of lever shown to give MA<br>• Suitable width of lever in comparison to square head.<br>• Square hole in one end of lever | 3 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(b)(iii) | Reasons could be:<br>• To allow ease of fitting lever to square head<br>• Taper will hold lever in place securely and allow for easy removal. | 1 | Allow other valid reasons |
| 11(b)(iv) | The tension is increased slightly to allow free movement of the pawl, 1 mark<br>Pawl is then lifted to allow shaft to rotate and fence wire to unwind, 1 mark | 2 | |
| 11(c)(i) | Each pair of pulleys gives a reduction of 3 : 1 (66 / 22), 1 mark<br>Total reduction is $3 \times 3 = 9 : 1$, 1 mark<br>Lathe output speed = 1215 / 9 = **135** rpm, 1 mark | 3 | |
| 11(c)(ii) | • The slots allow motor to be fitted/fixed in a suitable position<br>• The belt from intermediate shaft to lathe pulley can be tensioned<br>1 mark for suitable reason. | 1 | |
| 11(d)(i) | **Bevel gear**, 1 mark. | 1 | |
| 11(d)(ii) | Features are:<br>• The lever action of the chuck key / first order lever<br>• The mechanical advantage of the bevel gears / driver smaller than driven | 4 | 1 mark each for features, 1 mark each for description of how the feature increases MA. |
| 11(d)(iii) | Large reduction in speed, 1 mark<br>More compact than other gear types, 1 mark<br>One-way action, no reverse, 1 mark | 2 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 12(a)(i) | Description could include:<br>• Number value<br>• Multiplier value / number of zeros<br>• Tolerance / amount of difference allowable to the stated value<br>$2 \times 1$ marks | 2 | 1 mark for each point mentioned, allow 2 marks for a detailed description of a single point. |
| 12(a)(ii) | **4.7 kΩ   4K7   4700 Ω** | 1 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 12(a)(iii) | Lowest value = **4.4 kΩ**, **4K4** or **4465 Ω,** 1 mark<br>Highest value = **4.9 kΩ**, **4K9** or **4935 Ω,** 1 mark | **2** | |
| 12(a)(iv) | I = 9 / 100 = **0.09** A, 1 mark.<br>P = V × 0.9 = **0.81 W**, 1 mark.<br><br>Circle around **1 W** power rating, 1 mark. | **3** | Allow ecf on last part of answer. |
| 12(b)(i) | <br>temporary method could be any type of plug and socket<br>Permanent method soldering. | **2** | Allow spot welding for permanent method. |
| 12(b)(ii) | **Resistance** is being measured, 1 mark. | **1** | |
| 12(b)(iii) | 0.00 = low or no resistance, 1 mark.<br>1 = very high or infinite resistance, 1 mark. | **2** | |
| 12(c)(i) | <br>1 mark for recognisable NOT gate. | **1** | Award mark for NAND or NOR gate configured as a NOT gate |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 12(c)(ii) | <br>Signal inverted, 1 mark. | 1 | |
| 12(c)(iii) | Resistance and capacitance converted to common units, 1 mark<br><br>Substitution into formula, **t = 1.1 × 22 000 × .0001**, 1 mark<br><br>**t = 2.42 s,** 1 mark. | 3 | Alternative conversions<br>$1.1 \times 22 \times 100 = 2420$ ms<br>$1.1 \times 0.022 \times 100 = 2.42$ s |
| 12(c)(iv) | Differences could include:<br>• A polarised capacitor must be fitted the correct way around in circuit<br>• Electrolytic / polarised capacitors can have much greater value.<br>• Electrolytic / polarised capacitors are generally larger than non-polarised. | 2 | Allow any other valid difference.<br>1 mark for each point mentioned, allow 2 marks for a detailed description of a single point. |
| 12(d)(i) | Information could include:<br>• Relay is DPDT.<br>• Each pole in switch can carry 100 V AC or 24 V DC<br>• Dimensions of the relay<br>• Pinout diagram of the relay<br>• Current rating<br>• Cost<br><div align="right">2 × 1 marks</div> | 2 | |
| 12(d)(ii) | A diode is used to protect the transistor from back emf caused by the relay coil. 1 mark. | 1 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 12(d)(iii) | <br>Diode connected across coil, 1 mark<br>Diode in reverse bias, 1 mark. | 2 | |