



# Cambridge IGCSE<sup>®</sup>

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**DESIGN & TECHNOLOGY**

**0445/04**

Paper 4 Systems & Control

**For examination from 2020**

MARK SCHEME

Maximum Mark: 50

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**Specimen**

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This document has **12** pages. Blank pages are indicated.

## 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.

### GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

### GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

### GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- 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
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- 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:

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).

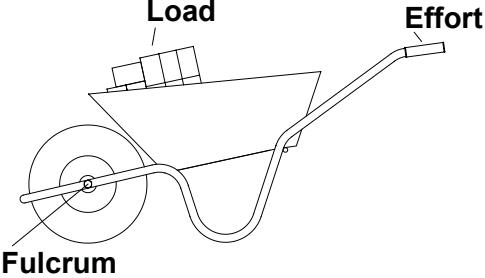
**GENERIC MARKING PRINCIPLE 6:**

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.

**Mark scheme key**

- The symbol / separates alternative answers that could be given for the same mark(s).
- Square brackets around a number show partial marks that can be awarded.
- Square brackets around text show extra information not needed for the mark(s) to be awarded.

| Question | Answer   | Marks | Guidance                           |
|----------|--|-------|------------------------------------|
| 1(a)     | Rotary [1] to reciprocating [1]                                | 2     |                                    |
| 1(b)     | [Roller is used] to reduce friction [against the cam profile]. | 1     | Allow reference to easier movement |

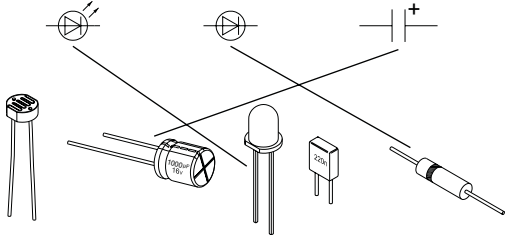
| Question | Answer  | Marks | Guidance |
|----------|---|-------|----------|
| 2        |  <p>Award 1 mark for each of the three correct. [3 × 1 mark]</p> | 3     |          |

| Question | Answer   | Marks | Guidance  |
|----------|--|-------|---|
| 3        | Appropriate method, e.g. two spur gears<br>Different direction of rotation [1]<br>Recognised method of transmission used [1]<br>Method clearly illustrated [1] | 3     | Allow crossed belt on a pulley or friction drive. |

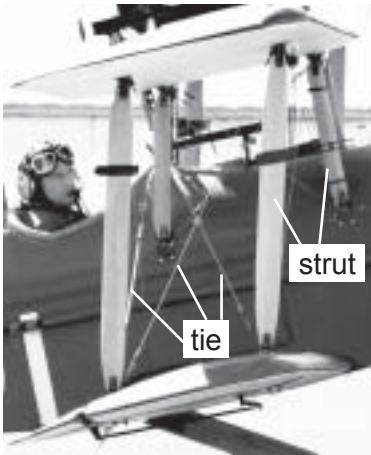
| Question | Answer   | Marks | Guidance   |
|----------|--|-------|--|
| 4(a)     | [The crack is caused by] shear [force].  | 1     | Allow reference to the weight of the wall or to gravity. |
| 4(b)     | Any <b>one</b> reason from:<br>movement in the ground /<br>foundation not strong enough /<br>earthquake damage | 1     |  |

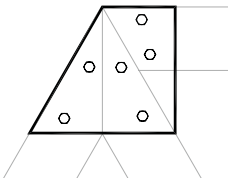
| Question | Answer  | Marks | Guidance  |
|----------|---|-------|---|
| 5(a)     | Torsion/torque  | 1     |   |
| 5(b)     | Compression   | 1     |   |
| 5(c)     | Award <b>2 marks</b> for response that explains <b>two</b> valid points.<br>The designer is responsible for the following factors in the safety of a product: <ul style="list-style-type: none"> <li>• Materials used to be specified</li> <li>• Construction methods to be specified</li> <li>• Monitoring of manufacture to be arranged</li> <li>• Potential loading to be taken into account</li> <li>• Assembly and fitting instructions to be provided.</li> </ul> | 2     | Allow 2 marks if one point well explained or justified.<br>E.g. of one point worth 2 marks:<br>'Any materials used must be specified in terms of grading of the material, types of glue used in plywood, carbon content of steel used.' |

| Question | Answer  | Marks | Guidance                                       |
|----------|---|-------|--|
| 6(a)     | Triangulation shown to increase rigidity in any <b>two</b> directions. [2 × 1 mark]   | 2     | 1 mark for each of two directions triangulated |
| 6(b)     | The [constant] weight (or load) [1] of component parts of the set of shelves [1], [which may include steel frame, shelves, screws and fixings]. | 2     |  |

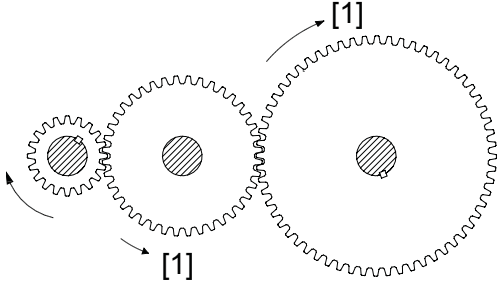
| Question | Answer  | Marks | Guidance   |
|----------|---|-------|--|
| 7        | Connections to <b>NC</b> [1] and <b>C</b> [1]   | 2     | No marks for any other combination of connections. |
| 8        | Award <b>1 mark</b> for <b>each</b> of the three correct. [3 × 1 mark]<br> | 3     | No marks for multiple lines                        |

| Question | Answer                         | Marks | Guidance         |
|----------|--------------------------------|-------|------------------|
| 9        | Ampere/milliamp/mA/microamp/μA | 1     | Accept 'amp(s)'. |

| Question      | Answer  | Marks    | Guidance  |
|---------------|---|----------|---|
| <b>EITHER</b> |   |          |   |
| 10(a)         | Sleeve/core used [1]<br>Suitable size for sleeve/core [1]<br>Suitable method of fixing each tube to sleeve indicated [1]  | <b>3</b> |   |
| 10(b)(i)      | Award <b>1 mark</b> for <b>one</b> correctly identified strut.<br>Award <b>1 mark</b> for <b>one</b> correctly identified tie.<br>[2 × 1 mark]<br> | <b>2</b> | Both a strut and a tie need to be identified to get 2 marks.<br>No second mark for identifying more than one of each. |
| 10(b)(ii)     | Compression   | <b>1</b> |   |
| 10(b)(iii)    | Tension   | <b>1</b> |   |
| 10(b)(iv)     | Frame structure   | <b>1</b> |   |

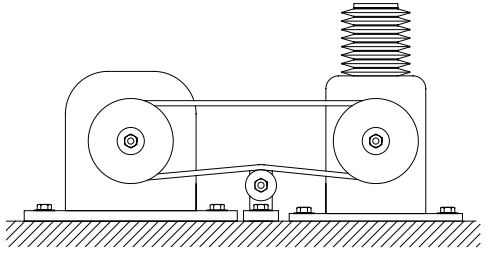
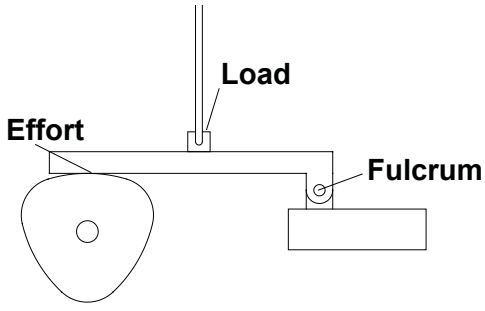
| Question   | Answer   | Marks | Guidance   |
|------------|--|-------|--|
| 10(c)(i)   | Suitable shape for gusset plate [1]<br>All parts of joint covered [1]<br>At least two fixing points in each piece of timber [1]<br>   | 3     |  |
| 10(c)(ii)  | Opposing forces are balanced [1]<br>The structure is not moving [1]  | 2     |  |
| 10(d)(i)   | Award <b>2 marks</b> for response that explains <b>two</b> valid points.<br>Explanation could include: <ul style="list-style-type: none"> <li>• Increased thickness compared to width will resist bending better</li> <li>• Fewer supports will be needed, saving on timber</li> <li>• The beam can span a greater distance safely.</li> </ul> | 2     | Explanation with two points, 2 marks.<br>Allow 2 marks for full explanation of a single point.<br>E.g. of one point worth 2 marks:<br>‘If fewer supports are used there will be a cost saving as well as a saving on resources.’ |
| 10(d)(ii)  | Any <b>three</b> valid points.<br>Factors could be: <ul style="list-style-type: none"> <li>• Expected static load</li> <li>• Expected dynamic load</li> <li>• Materials degrading or corroding over time</li> <li>• Weaknesses in joining or fixing methods.</li> </ul> [3 × 1 mark]   | 3     | Allow other valid responses.   |
| 10(d)(iii) | Any <b>two</b> defects for 1 mark <b>each</b> .<br>This could include: splits / shakes / knots / warping / insect damage.  | 2     | Allow other valid responses.   |

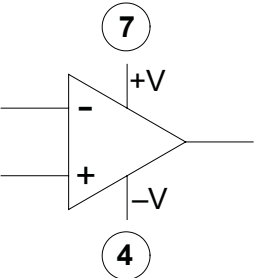
| Question  | Answer   | Marks | Guidance   |
|-----------|--|-------|--|
| 10(e)(i)  | Any <b>two</b> advantages of aluminium over timber.<br>These could include: <ul style="list-style-type: none"> <li>• light-weight</li> <li>• will not rot</li> <li>• no natural defects</li> <li>• no termite or insect damage</li> <li>• rigid</li> <li>• easier to manufacture</li> <li>• extruded rungs can have grip on.</li> </ul> [2 × 1 mark] | 2     | Allow other suitable advantages.   |
| 10(e)(ii) | $R_2 \times 370 = 250 \times 750$ [1]<br>$R_2 = 187\,500/370 = \mathbf{506.76\,N}$ [1]<br>$R_1 = 750 - 506.76 = \mathbf{243.24\,N}$ [1]  | 3     | Allow 3 marks for correct $R_1$ and $R_2$ results with no working, as method mark implied. |

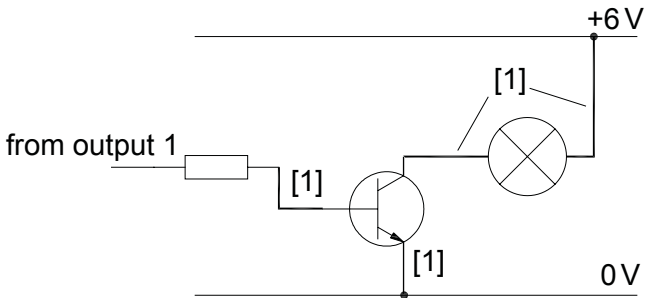
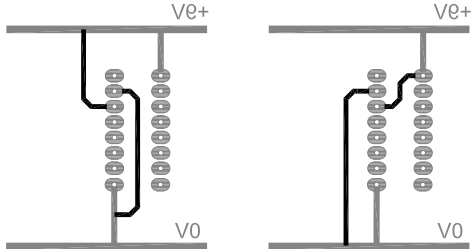
| Question   | Answer  | Marks | Guidance   |
|------------|---|-------|--|
| <b>OR</b>  |   |       |  |
| 11(a)(i)   | 1 mark for <b>each</b> correct direction arrow added.<br> | 2     |  |
| 11(a)(ii)  | Gear ratio is 3:1 [1]<br>Gear C rotates at <b>20rpm</b> [1]   | 2     | Allow 2 marks for 20rpm with no working, as gear ratio mark implied.     |
| 11(a)(iii) | Gear <b>B</b> , the idler gear can rotate freely [1], as it is not being driven by a shaft or transferring drive to a shaft. [1]            | 2     | 2 marks for clear explanation.<br>1 mark for reference to free rotation. |



| Question  | Answer   | Marks    | Guidance   |
|-----------|--|----------|--|
| 11(b)     | <p><b>One</b> benefit for a ball race [1], e.g.</p> <ul style="list-style-type: none"> <li>reduced contact area</li> <li>can resist thrust</li> <li>easily replaced</li> <li>low rolling friction</li> <li>commonly used so a wide range is available.</li> </ul> <p><b>One</b> benefit for a roller race [1], e.g.</p> <ul style="list-style-type: none"> <li>reduced contact area</li> <li>will take greater radial load than ball bearing.</li> </ul>   | <b>2</b> | Allow other valid benefits.  |
| 11(c)(i)  | <p>Award <b>1 mark</b> for <b>each</b> point in the explanation up to a <b>maximum of 3</b>.<br/>Points could include:</p> <ul style="list-style-type: none"> <li>A worm gear will give a large reduction in speed and increase in torque at the worm wheel</li> <li>The lift car plus occupants can be very heavy so increased torque is needed</li> <li>A worm drive can only operate in one direction so the lift car cannot slip back</li> <li>A worm wheel can be effectively lubricated to reduce wear.</li> </ul> <p>[3 × 1 mark]</p> | <b>3</b> | <p>Allow 2 marks for a single point explained in depth.<br/>E.g. of one point worth 2 marks:<br/>'The reduction in speed produced by a worm wheel is equivalent to using a single tooth spur gear, it will also take up less space to provide the same reduction as spur gears.'</p> |
| 11(c)(ii) | <p>Award <b>1 mark</b> for <b>one</b> valid reason. Reasons could include:</p> <ul style="list-style-type: none"> <li>To spread the load over more than one cable</li> <li>If one cable breaks the others can take the extra strain</li> <li>Increased surface area of cable in contact with the pulley to prevent slipping.</li> </ul>  | <b>1</b> | Allow other valid responses.   |
| 11(d)(i)  | <p>Award <b>1 mark</b> for <b>one</b> suitable benefit:</p> <ul style="list-style-type: none"> <li>Vee belt cannot move sideways off the pulley</li> <li>Greater contact area on pulley.</li> </ul>  | <b>1</b> | Allow other valid responses.   |
| 11(d)(ii) | <p>Flat belt /<br/>Toothed belt /<br/>Round belt</p>   | <b>1</b> |  |

| Question   | Answer  | Marks    | Guidance  |
|------------|---|----------|---|
| 11(d)(iii) | <p>Award <b>0–4 marks</b>, following the guidance.<br/>Method of adjustment could be:</p> <ul style="list-style-type: none"> <li>• Adjustable idler pulley against belt in fixed position</li> <li>• Spring loaded idler pulley held against belt</li> <li>• Slots in the base of motor or compressor to allow them to be moved apart.</li> </ul>  | <b>4</b> | Functional method [1].<br>Sketch only [1] <b>OR</b> sketches and notes [2].<br>Quality of sketches [1]. |
| 11(e)(i)   | <p>Award <b>1 mark</b> for <b>each</b> of the three correct [3 × 1 mark]</p>    | <b>3</b> |   |
| 11(e)(ii)  | The lever is second order / second class. [1]   | <b>1</b> |   |
| 11(e)(iii) | The follower will rise and fall [1], this will happen three times [1].<br>Award <b>2 marks</b> for any <b>two</b> correct statements.   | <b>2</b> |   |
| 11(e)(iv)  | [To allow the connection at the other end of the rod to be in a fixed horizontal position.] As the lever follower moves, joint Y moves in an arc and the joint would have to pivot [because the linkage rod does not stay vertical].  | <b>1</b> | Allow 1 mark for understanding shown.<br>Award the mark for text outside of brackets or equivalent.     |

| Question                              | Answer  | Marks           | Guidance   |                                       |                                  |                                       |                                 |          |  |
|---------------------------------------|---|-----------------|--|---------------------------------------|----------------------------------|---------------------------------------|---------------------------------|----------|--|
| <b>OR</b>                             |   |                 |  |                                       |                                  |                                       |                                 |          |  |
| 12(a)                                 | <b>A</b> = conductors crossing but not connected [1]<br><b>B</b> = junction, conductors connected [1]<br><b>C</b> = Earth/ground [1]  | <b>3</b>        |  |                                       |                                  |                                       |                                 |          |  |
| 12(b)                                 | Any <b>two</b> relevant points:<br>LEDs can differ in size / shape / intensity / angle of light output / frequency of light emitted (IR).   | <b>2</b>        | Allow any other valid difference.  |                                       |                                  |                                       |                                 |          |  |
| 12(c)                                 | Capacitor value $470\ \mu\text{F}$ [1]<br>Resistor value $2\ \text{M}\Omega$ [1]  | <b>2</b>        |  |                                       |                                  |                                       |                                 |          |  |
| 12(d)(i)                              | Power connections 4 and 7 correct, 1 mark <b>each</b> .<br>  | <b>2</b>        |  |                                       |                                  |                                       |                                 |          |  |
| 12(d)(ii)                             | <table border="1"> <thead> <tr> <th>Input condition</th> <th>Approximate output voltage</th> </tr> </thead> <tbody> <tr> <td>inverting input &gt; non-inverting input</td> <td>output is <b>close to 0V</b> [1]</td> </tr> <tr> <td>non-inverting input &gt; inverting input</td> <td>output is <b>above 5.0V</b> [1]</td> </tr> </tbody> </table>        | Input condition | Approximate output voltage   | inverting input > non-inverting input | output is <b>close to 0V</b> [1] | non-inverting input > inverting input | output is <b>above 5.0V</b> [1] | <b>2</b> |  |
| Input condition                       | Approximate output voltage  |                 |  |                                       |                                  |                                       |                                 |          |  |
| inverting input > non-inverting input | output is <b>close to 0V</b> [1]  |                 |  |                                       |                                  |                                       |                                 |          |  |
| non-inverting input > inverting input | output is <b>above 5.0V</b> [1]   |                 |  |                                       |                                  |                                       |                                 |          |  |
| 12(e)                                 | Any <b>two</b> relevant points. Points could include: <ul style="list-style-type: none"> <li>NC and NO contacts are joined, each junction going to a power rail</li> <li>Motor contacts are connected to common terminals of each switch</li> <li>When switch is operated the motor connections to the power source are reversed.</li> </ul> [2 × 1 mark] | <b>2</b>        | Allow marks for understanding shown.<br>E.g. the motor is reversed by changing the polarity of the supply. |                                       |                                  |                                       |                                 |          |  |

| Question   | Answer  | Marks | Guidance   |
|------------|---|-------|--|
| 12(f)(i)   | AND gates [1], NOT gates or inverters [1].  | 2     |  |
| 12(f)(ii)  | When switch 1 is pressed, a logic 1 signal goes to AND gate <b>A</b> ; the other input is from NOT gate <b>D</b> which is a logic 1 signal; this makes the output of gate <b>A</b> logic 1. [1]<br>As soon as gate <b>A</b> output has changed, NOT gate <b>C</b> will send a logic 0 signal to an input of AND gate <b>B</b> , preventing the gate from giving a logic 1 output. [1] | 2     | Allow marks for understanding of each stage, 2 × 1 marks.  |
| 12(f)(iii) | Resistor to transistor base [1], emitter to 0V [1], two lamp connections [1].<br>  | 3     | Maximum of 2 marks if any incorrect connections.   |
| 12(g)(i)   | Use of voltage drop $9\text{V} - 2\text{V} = 7\text{V}$ [1]<br>Correct formula used and substitution made $R = V/I$ $R = 7/0.015$ [1]<br>$R = 466.6\Omega$ [1]  | 3     | Allow $466\Omega$ or $467\Omega$ .<br>Allow 3 marks for correct answer for R with no working shown, as method marks implied. |
| 12(g)(ii)  | <br>1 mark for <b>each</b> track correct.   | 2     | Other solutions are possible, allow the use of a bridge.   |