



# Cambridge International AS & A Level

**MATHEMATICS**

**9709/04**

Paper 4 Mechanics

**For examination from 2020**

**MARK SCHEME**

Maximum Mark: 50

**Specimen**

---

This document has **10** 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 Notes**

Marks are of the following three types.

|          |   |
|----------|---|
| M        | Method mark, given for a valid method applied to the problem. Method marks can still be given even if there are numerical errors, algebraic slips or errors in units. However the method must be applied to the specific problem, e.g. by substituting the relevant quantities into a formula. Correct use of a formula without the formula being quoted earns the M mark and in some cases an M mark can be implied from a correct answer. |
| A        | Accuracy mark, given for an accurate answer or accurate intermediate step following a correct method. Accuracy marks cannot be given unless the relevant method mark has also been given.   |
| B        | Mark for a correct statement or step.   |
| DM or DB | M marks and B marks are generally independent of each other. The notation DM or DB means a particular M or B mark is dependent on an earlier M or B mark (indicated by *). When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.  |

- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT below).
- Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures (sf) or would be correct to 3 sf if rounded (1 decimal point (dp) for angles in degrees). As stated above, an A or B mark is not given if a correct numerical answer is obtained from incorrect working.
- Common alternative solutions are shown in the Answer column as: ‘**EITHER** Solution 1 **OR** Solution 2 **OR** Solution 3 ...’. Round brackets appear in the Partial Marks column around the marks for each alternative solution.
- Square brackets [ ] around text show extra information not needed for the mark to be awarded.
- The total number of marks available for each question is shown at the bottom of the Marks column in bold type.

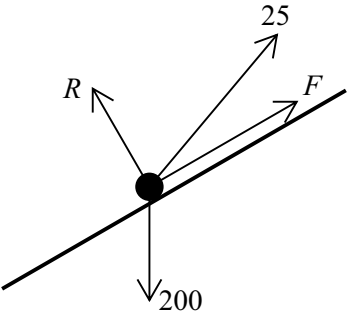
The following abbreviations may be used in a mark scheme.

|     |  |
|-----|--|
| AG  | Answer given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid). |
| CAO | Correct answer only (emphasising that no ‘follow through’ from an error is allowed).   |
| CWO | Correct working only   |
| FT  | Follow through after error (see Mark Scheme Notes for further details).  |
| ISW | Ignore subsequent working  |
| OE  | Or equivalent form   |
| SC  | Special case   |
| SOI | Seen or implied  |

| Question | Answer                    | Marks    | Partial Marks | Guidance   |
|----------|---------------------------|----------|---------------|--|
| 1(a)     | $0 = 20^2 - 20s$          | 1        | <b>M1</b>     | For using $v^2 = u^2 + 2as$ with $a = -10$ to find $s$ , the greatest height reached                 |
|          | $s = 20 \text{ m}$        | 1        | <b>A1</b>     |  |
|          |                           | <b>2</b> |               |  |
| 1(b)     | $0 = 20 - 10t$<br>$t = 2$ | 1        | <b>M1</b>     | For using $v = u + at$ with $v = 0$ , $u = 20$ and $a = -10$ to find the time to the greatest height |
|          | Total time 4 s            | 1        | <b>A1</b>     |  |
|          |                           | <b>2</b> |               |  |

| Question | Answer  | Marks    | Partial Marks | Guidance   |
|----------|---|----------|---------------|--|
| 2(a)     | $[DF = 1350]$ Power = $1350 \times 32$                      | 1        | <b>M1</b>     |  |
|          | = 43.2 kW   | 1        | <b>A1</b>     |  |
|          |   | <b>2</b> |               |  |
| 2(b)     | $DF - 1350 + 1200g \times \frac{1}{20} = 0$<br>$[DF = 750]$ | 1        | <b>M1</b>     | For using Newton's 2nd law applied to the car down the hill (3 terms)<br>Allow use of $\theta = 2.9^\circ$ |
|          | $31\,500 = \text{their } (750) \times v$                    | 1        | <b>M1</b>     | For using $DF = \frac{P}{v}$   |
|          | $v = 42 \text{ m s}^{-1}$                                   | 1        | <b>A1</b>     |  |
|          |   | <b>3</b> |               |  |

| Question | Answer  | Marks    | Partial Marks | Guidance  |
|----------|---|----------|---------------|---|
| 3(a)     | Conservation of momentum<br>$4 \times 6 [+ 0] = 4 \times 2 + 2v$  | 1        | <b>M1</b>     | For applying conservation of momentum   |
|          | $v = 8 [\text{m s}^{-1}]$   | 1        | <b>A1</b>     |   |
|          |   | <b>2</b> |               |   |
| 3(b)     | $2 \times \text{their } (8) [+ 0] = 2v + 3v$  | 1        | <b>M1</b>     | For applying conservation of momentum   |
|          | $v = 3.2 [\text{m s}^{-1}]$   | 1        | <b>A1</b>     |   |
|          |   | <b>2</b> |               |   |
| 3(c)     | Kinetic energy (KE) initial = $\frac{1}{2} \times 4 \times 6^2$<br>KE final = $\frac{1}{2} \times 4 \times 2^2 + \frac{1}{2} \times 5 \times 3.2^2$ | 1        | <b>M1</b>     | For use of $\frac{1}{2} \times m \times v^2$ , when either initial or final calculation correct using their value from <b>(b)</b> |
|          | Loss of KE = $72 - 33.6 = 38.4 [\text{J}]$  | 1        | <b>A1</b>     | AG For all correct  |
|          |   | <b>2</b> |               |   |

| Question | Answer   | Marks | Partial Marks | Guidance                          |
|----------|--|-------|---------------|-----------------------------------|
| 4(a)     | Correct force diagram with 3 extra forces shown<br> | 1     | B1            | Accept 200 or 20 g for weight     |
| 4(b)     | For resolving forces in the direction parallel to and/or perpendicular to the plane  | 1     | M1            |                                   |
|          | $F + 25 \cos 20^\circ = 20 \times g \times \sin 30^\circ$  | 1     | A1            |                                   |
|          | $R + 25 \sin 20^\circ = 20 \times g \times \cos 30^\circ$  | 1     | A1            |                                   |
|          | [ $F = 76.5\dots$ ]<br>[ $R = 164.65\dots$ ]<br>$\mu = \frac{\text{their } (76.5\dots)}{\text{their } (164.65\dots)}$                | 1     | M1            | Use $F = \mu R$ to evaluate $\mu$ |
|          | = 0.465  | 1     | A1            |                                   |
|          |  | 5     |               |                                   |

| Question | Answer   | Marks    | Partial Marks | Guidance  |
|----------|--|----------|---------------|---|
| 5(a)     | $2500 - 2000g \times 0.1 - 400 = 2000a$  | 1        | <b>M1</b>     | For Newton's 2nd law  |
|          | $a = 0.05 \text{ m s}^{-2}$  | 1        | <b>A1</b>     |   |
|          | $2500 - T - 300 - 1200g \times 0.1 = 1200 \times 0.05$<br><b>OR</b><br>$T - 100 - 800g \times 0.1 = 800 \times 0.05$ | 1        | <b>M1</b>     | For Newton's 2nd law to either car or trailer to give an equation for $T$ . |
|          | $T = 940 \text{ N}$  | 1        | <b>A1</b>     |   |
|          |  | <b>4</b> |               |   |
| 5(b)     | $-2000g \times 0.1 - 400 = 2000a$<br>[ $a = -1.2$ ]  | 1        | <b>M1</b>     | For Newton's 2nd law  |
|          | $0 = 30 - 1.2t$  | 1        | <b>M1</b>     | For using $v = u + at$  |
|          | $t = 25 \text{ s}$   | 1        | <b>A1</b>     |   |
|          | $T - 100 - 800g \times 0.1 = 800 \times -1.2$  | 1        | <b>M1</b>     | For applying Newton's second law to the trailer or to the car               |
|          | $T = -60 \text{ N}$  | 1        | <b>A1</b>     | Accept (thrust) = 60N   |
|          |  | <b>5</b> |               |   |

| Question | Answer  | Marks | Partial Marks | Guidance  |
|----------|---|-------|---------------|---|
| 6(a)     | $k = 40$  | 1     | <b>B1</b>     |   |
| 6(b)     | <p> <math display="block">\left[ \begin{array}{ll} y = 5x^2 - 10x &amp; \text{for } 0 \leq x \leq 4, \\ y = 40 &amp; \text{for } 4 \leq x \leq 14, \\ y = 68 - 2x &amp; \text{for } 14 \leq x \leq 20 \end{array} \right]</math> </p>                         | 1     | <b>B1FT</b>   | Correct for $0 \leq t \leq 4$<br>For quad graph, min at $t = 1$ ; FT on $k$   |
|          |   | 1     | <b>B1FT</b>   | Correct for $4 \leq t \leq 14$<br>For horizontal line at $v = k$ ; FT on $k$  |
|          |   | 1     | <b>B1FT</b>   | Correct for $14 \leq t \leq 20$<br>For line with negative gradient from $(14, k)$ to $(20, 28)$ [gradient = $-2$ ]; FT on $k$ |
|          |   | 3     |               |   |
| 6(c)     | $a = 10t - 10$  | 1     | <b>M1</b>     | For attempting to differentiate to find $a$   |
|          | $1 < t < 4$   | 1     | <b>A1</b>     | Allow $\leq$ at 4 but not at 1  |
|          |   | 2     |               |   |
| 6(d)     | Dist =<br>$\left  \int_0^2 (5t^2 - 10t) dt \right  + \int_2^4 (5t^2 - 10t) dt + (40 \times 10) + (0.5 \times (40 + 28) \times 6)$<br>$= \left[ \frac{5}{3}t^3 - 5t^2 \right]_0^2 + \left[ \frac{5}{3}t^3 - 5t^2 \right]_2^4 + 400 + 204$<br>$= 644 \text{ m}$ | 1     | <b>M1</b>     | For attempting to integrate   |
|          |   | 1     | <b>A1</b>     | For correct expression including limits and the distance travelled over full 20 s   |
|          |   | 1     | <b>B1</b>     | For correct integration   |
|          |   | 1     | <b>A1FT</b>   | FT on their $k$   |
|          |   | 1     | <b>A1</b>     |   |
|          |   | 5     |               |   |



| Question        | Answer  | Marks    | Partial Marks | Guidance   |
|-----------------|---|----------|---------------|--|
| 7(a)            | <b>EITHER</b> Solution 1<br>$T = 0.8a$ for $A$<br>$0.2g - T = 0.2a$ for $B$<br>$0.2g = (0.2 + 0.8)a$ for system | 2        | <b>(M1M1)</b> | M1 for applying Newton's 2nd law either to particle $A$ or to particle $B$ or to the system<br>M1 for applying Newton's 2nd law to a second particle (if needed) and solving for $a$ |
|                 | $a = 2$   | 1        | <b>A1</b>     |  |
|                 | $2.5 = 0.5 \times 2 \times t^2$   | 1        | <b>M1</b>     | For using a complete method for finding $t$ such as using $s = ut + \frac{1}{2}at^2$   |
|                 | $t = 1.58$ s  | 1        | <b>A1)</b>    | Allow $t = \frac{1}{2}\sqrt{10}$   |
|                 | <b>OR</b> Solution 2<br>$0.2 \times g \times 2.5$ <b>OR</b> $\frac{1}{2}(0.2 + 0.8)v^2$                         | 1        | <b>(M1)</b>   | For finding potential energy (PE) loss or KE gain (system)   |
|                 | $0.2 \times g \times 2.5 = \frac{1}{2}(0.2 + 0.8)v^2$   | 1        | <b>M1</b>     | For using PE loss = KE gain and finding $v$  |
|                 | $v^2 = 10$  | 1        | <b>A1</b>     |  |
|                 | $2.5 = \frac{1}{2}(0 + \sqrt{10})t$   | 1        | <b>M1</b>     | For using $s = \frac{1}{2}(u + v)t$  |
|                 | $t = 1.58$ s  | 1        | <b>A1)</b>    | Allow $t = \frac{1}{2}\sqrt{10}$   |
|                 | <b>OR</b> Solution 3<br>$T = 0.8a$ $0.2g - T = 0.2a$<br>$\rightarrow T = 1.6$ N                                 | 1        | <b>(M1)</b>   | For applying Newton's 2nd law to $A$ and $B$ and solving for $T$   |
|                 | $T \times 2.5 = \frac{1}{2}(0.8)v^2$  | 1        | <b>M1</b>     | For using work done (WD) by $T$ = KE gain by $A$ , find $v$  |
|                 | $v^2 = 10$  | 1        | <b>A1</b>     |  |
|                 | $2.5 = \frac{1}{2}(0 + \sqrt{10})t$   | 1        | <b>M1</b>     | For using $s = \frac{1}{2}(u + v)t$  |
|                 | $t = 1.58$ s  | 1        | <b>A1)</b>    | Allow $t = \frac{1}{2}\sqrt{10}$   |
| Available marks |   | <b>5</b> |               |  |

| Question | Answer  | Marks    | Partial Marks | Guidance   |
|----------|---|----------|---------------|--|
| 7(b)     | $0.2 \times g \times 2.5 = \frac{1}{2}(0.8 + 0.2)v^2 + 2$ | 2        | <b>M1A1</b>   | M1 For applying work/energy to the system as<br>PE loss = KE gain + WD against resistance<br>A1 For correct work/energy equation |
|          | For solving for $v$                                       | 1        | <b>M1</b>     |  |
|          | $v = \sqrt{6}$ (or 2.45)                                  | 1        | <b>A1</b>     |  |
|          |   | <b>4</b> |               |  |