CAMBRIDGE
International Education

# Cambridge International AS & A Level

**FURTHER MATHEMATICS** **9231/33**

Paper 3 Further Mechanics **May/June 2026**

MARK SCHEME

Maximum Mark: 50

**Published**

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.



© Cambridge University Press & Assessment 2026 

**General marking principles**

All examiners must apply these marking principles when marking candidate responses.

| | |
|---|---|
| 1 | Examiners must award marks for each response in line with:<br><br>• the specific **content** defined in the mark scheme<br>• the specific **skills** defined in the mark scheme or in the level descriptions<br>• the **standard of response** required as exemplified by the standardisation scripts. |
| 2 | Examiners must award **whole marks** (not half marks, or other fractions). |
| 3 | Examiners must award marks **positively**. This means that:<br><br>• marks are not deducted for errors or omissions<br>• marks are awarded for correct/valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate<br>• the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous. |
| 4 | Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly. |
| 5 | Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen. |
| 6 | Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind. |

© Cambridge University Press & Assessment 2026

**Mathematics Specific Marking Principles**

1 Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.

2 Unless specified in the question, non-integer answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.

3 Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.

4 Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (ISW).

5 Where a candidate has misread a number or sign in the question and used that value consistently throughout, provided that number or sign does not alter the difficulty or the method required, award all marks earned and deduct just 1 A or B mark for the misread.

6 Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

© Cambridge University Press & Assessment 2026

**Annotations guidance for centres**

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

**Annotations**

| Annotation | Meaning |
|---|---|
|  | More information required |
|  | Accuracy mark awarded zero |
|  | Accuracy mark awarded one |
|  | Independent accuracy mark awarded zero |
|  | Independent accuracy mark awarded one |
|  | Independent accuracy mark awarded two |
|  | Benefit of the doubt |
|  | Blank Page |
|  | Incorrect |
| Dep | Used to indicate DM0 or DM1 |

© Cambridge University Press & Assessment 2026

| **Annotation** | **Meaning** |
|---|---|
| DM1 | Dependent on the previous M1 mark(s) |
| FT | Follow through |
|  | Indicate working that is right or wrong |
| Highlighter | Highlight a key point in the working |
| ISW | Ignore subsequent work |
| J | Judgement |
| JU | Judgement |
| M0 | Method mark awarded zero |
| M1 | Method mark awarded one |
| M2 | Method mark awarded two |
| MR | Misread |
| O | Omission or Other solution |
| Off-page comment | Allows comments to be entered at the bottom of the RM marking window and then displayed when the associated question item is navigated to. |
| On-page comment | Allows comments to be entered in speech bubbles on the candidate response. |
| PE | Judgment made by the PE |
| Pre | Premature approximation |
| SC | Special case |

© Cambridge University Press & Assessment 2026

| Annotation | Meaning |
|---|---|
| SEEN | Indicates that work/page has been seen |
| SF | Error in number of significant figures |
|  | Correct |
| TE | Transcription error |
| XP | Correct answer from incorrect working |

© Cambridge University Press & Assessment 2026

**PUBLISHED**

## Mark Scheme Notes

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

### Types of mark

**M** Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

**A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

**B** Mark for a correct result or statement independent of method marks.

**DM** or **DB** When a part of a question has two or more 'method' steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

**FT** Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.

- 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 above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
- The total number of marks available for each question is shown at the bottom of the Marks column.
- Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
- Square brackets [ ] around text or numbers show extra information not needed for the mark to be awarded.

© Cambridge University Press & Assessment 2026

**Abbreviations**

| | |
|---|---|
| AEF/OE | Any Equivalent Form (of answer is equally acceptable) / Or Equivalent |
| 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 a previous error is allowed) |
| CWO | Correct Working Only |
| ISW | Ignore Subsequent Working |
| SOI | Seen Or Implied |
| SC | Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance) |
| WWW | Without Wrong Working |
| AWRT | Answer Which Rounds To |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1 | ↑ $R\cos\theta = mg$ | **B1** | Resolve vertically. |
| | ← $R\sin\theta = m(a\sin\theta)\omega^2$ | **B1** | Resolve horizontally.<br>**B1** for $R = ma\omega^2$ (with $\sin\theta$ cancelled).<br>**B0** for $R\sin\theta = mr\omega^2$ unless $r$ replaced with $a\sin\theta$ later in working.<br>**B1** for $R\sin\theta = ma\frac{\sqrt{5}}{3}\omega^2$.<br>Sight of $mg\tan\theta = m(a\sin\theta)\omega^2$ earns **B1 B1**. |
| | $g = (a\cos\theta)\omega^2$ or $\omega^2 = \frac{g}{a\cos\theta}$ or $\cos\theta = \frac{g}{a\omega^2}$ | **M1** | OE, eliminate $R$ and $m$ to get an expression in $\omega^2$.<br>Must be obtained from equations with sin/cos mix only.<br>$\tan\theta = \frac{\frac{1}{3}\sqrt{5}a\omega^2}{g}$ |
| | $\frac{1}{3}a = a - a\cos\theta$, $\cos\theta = \frac{2}{3}$ | **B1** | $\frac{1}{2}\sqrt{5} = \frac{\frac{1}{3}\sqrt{5}a\omega^2}{g}$ |
| | $\omega = \sqrt{\frac{3g}{2a}}$ | **A1** | OE, for example, $1.22\sqrt{\frac{g}{a}}$. |
| | | **5** | |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2 | **EITHER:**<br>$mv\frac{\mathrm{d}v}{\mathrm{d}x}=-k\frac{1}{x^2}$ | **(*B1** | N2L to form a differential equation in terms of $v\frac{\mathrm{d}v}{\mathrm{d}x}$.<br>Accept $\pm k$.<br>**B0** for $mv\frac{\mathrm{d}v}{\mathrm{d}x}=-k\frac{1}{d^2}$. |
| | $\int mv\,\mathrm{d}v=-\int\frac{k}{x^2}\mathrm{d}x$ leading to $\frac{mv^2}{2}=\frac{k}{x}+c$ | ***M1** | Separate variables correctly and integrate to obtain an equation of the form $mv^2=\frac{\alpha}{x}(+c)$ where $\alpha\neq 0$.<br>Condone omission of $+c$. |
| | $\left[\frac{\frac{1}{2}mv^2}{\frac{1}{2}mu^2}=\frac{1}{4}\right]$ $v^2=\frac{1}{4}u^2$ or $v=\frac{1}{2}u$ | ***B1** | Use kinetic energy loss to find $v$ when $x=\frac{1}{2}d$.<br>Implied by $x=\frac{1}{2}d$ and $v=\frac{1}{2}u$ as a boundary condition. |
| | $x=d, v=u \Rightarrow \frac{mu^2}{2}=\frac{k}{d}+c$<br>$x=\frac{1}{2}d, v=\frac{1}{2}u \Rightarrow \frac{mu^2}{8}=\frac{2k}{d}+c$ | **DM1** | Use both sets of boundary conditions correctly to obtain two equations in $c$, $k$ and $d$ using *their* $\frac{mv^2}{2}=\frac{k}{x}+c$.<br>Be aware $k$ can be negative here, $k=\mp\frac{3}{8}mdu^2$.<br>$c$ may already have been found, $c=\pm\frac{7}{8}mu^2$.<br>$\frac{1}{4}\left(\frac{k}{d}+c\right)=\frac{2k}{d}+c$ implies **B1M1**. |
| | $0=\frac{-\frac{3}{8}mdu^2}{x}+\frac{7mu^2}{8}$ | **DM1** | **Dependent on all marks so far.**<br>Substitute $v=0$.<br>$c=-\frac{7k}{3d} \Rightarrow 0=\frac{k}{d}-\frac{7k}{3d}$ |
| | $\frac{3}{7}d$ | **A1)** | **SC B3 for correct answer if *m* is not present throughout.** |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2 | **OR:**<br>**Alternative method with *x* measured from *A*.**<br>$mv\frac{\mathrm{d}v}{\mathrm{d}x}=-k\frac{1}{(d-x)^2}$ | **(*B1** | N2L to form a differential equation in terms of $v\frac{\mathrm{d}v}{\mathrm{d}x}$.<br>Accept $\pm k$. |
| | $\int mv\,\mathrm{d}v=-\int\frac{k}{(d-x)^2}\mathrm{d}x$ leading to $\frac{mv^2}{2}=-\frac{k}{(d-x)}+c$ | ***M1** | Separate variables correctly and integrate to obtain an equation of the form $mv^2=\frac{\alpha}{(d-x)}(+c)$ where $\alpha\neq 0$.<br>Condone omission of $+c$. |
| | $\left[\frac{\frac{1}{2}mv^2}{\frac{1}{2}mu^2}=\frac{1}{4}\right]$ $v^2=\frac{1}{4}u^2$ or $v=\frac{1}{2}u$ | ***B1** | Use kinetic energy loss to find $v$ when $x=\frac{1}{2}d$.<br>Implied by $x=\frac{1}{2}d$ and $v=\frac{1}{2}u$ as a boundary condition. |
| | $x=0, v=u \Rightarrow \frac{mu^2}{2}=-\frac{k}{d}+c$<br>$x=\frac{1}{2}d, v=\frac{1}{2}u \Rightarrow \frac{mu^2}{8}=-\frac{k}{\left(d-\frac{1}{2}d\right)}+c$ | **DM1** | Use both sets of boundary conditions correctly to obtain two equations in *c, k* and *d* using *their* $\frac{mv^2}{2}=-\frac{k}{(d-x)}+c$.<br>Be aware *k* can be negative here, $k=\pm\frac{3}{8}mdu^2$.<br>*c* may already have been found, $c=\pm\frac{7}{8}mu^2$. |
| | $0=\frac{\frac{3}{8}mdu^2}{(d-x)}+\frac{7mu^2}{8}$ | **M1** | **Dependent on all marks so far.**<br>Substitute $v=0$. |
| | $x=\frac{4}{7}d$, minimum distance $=d-\frac{4}{7}d=\frac{3}{7}d$ | **A1)** | **SC B3 for correct answer if *m* is not present throughout.** |
| | Available marks | **6** | |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 3 | At $B$, $mg\cos\beta = \frac{mv^2}{a}$ | **B1** | N2L radially. If their equation contains $R$, only award this mark when $R$ is set to 0. |
| | $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mga(\cos\alpha - \cos\beta)$ | ***M1** | Energy equation with 4 terms and correct dimensions (mass must be present). Allow sign errors and sin/cos mix only. |
| | | **A1** | Fully correct energy equation. |
| | $ag\cos\beta - \left(\frac{2}{3}\right)^2 ag\cos\beta = 2ag(\cos\alpha - \cos\beta)$ | **DM1** | Combine *their* two equations and substitute $u = \frac{2}{3}v$ to obtain an equation in, for example, $\cos\alpha$ and $\cos\beta$ only.<br>Allow sin/cos mix only in *their* N2L equation radially.<br>May, instead, see the following:<br>$\cos\beta - \left(\frac{2}{3}\right)^2 \cos\beta = 2(\cos\alpha - \cos\beta)$<br>$\cos\beta - \frac{4}{9}\cos\beta = 2(\cos\alpha - \cos\beta)$ |
| | $\cos\alpha : \cos\beta = 23 : 18$ | **A1** | OE |
| | | **5** | |

© Cambridge University Press & Assessment 2026

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td rowspan="4">4(a)</td><td rowspan="3">$\left(d^3+\frac{1}{3}d^2h(k+1)\right)\bar{x}=\frac{1}{3}khd^2\left(\frac{1}{2}d+\frac{1}{4}kh\right)$</td><td>M1</td><td>Dimensionally correct moments equation, which must be of the form $\left(\alpha d^3+\beta d^2h(k+1)\right)\bar{x}=khd^2\left(\gamma d+\delta kh\right)$ where $\alpha,\beta,\gamma,\delta$ are all non-zero constants.<br>For reference:<br><table><tr><td></td><td>Volume</td><td>From $AB$</td></tr><tr><td>Cube</td><td>$d^3$</td><td>0</td></tr><tr><td>Vertical pyramid</td><td>$\frac{1}{3}hd^2$</td><td>0</td></tr><tr><td>Horizontal pyramid</td><td>$\frac{1}{3}khd^2$</td><td>$\frac{1}{2}d+\frac{1}{4}kh$</td></tr><tr><td>Object</td><td>$d^3+\frac{1}{3}d^2h(k+1)$</td><td>$\bar{x}$</td></tr></table></td></tr>
<tr><td>B1</td><td>Either side of equation correct.</td></tr>
<tr><td>A1</td><td>Fully correct moments equation.</td></tr>
<tr><td>$\bar{x}=\frac{kh(2d+kh)}{4(hk+h+3d)}$</td><td>A1</td><td>OE, for example, $\frac{\frac{1}{3}khd^2\left(\frac{1}{2}d+\frac{1}{4}kh\right)}{d^3+\frac{1}{3}d^2h(k+1)}$ or $\frac{2dkh+k^2h^2}{12d+4kh+4h}$.<br>ISW</td></tr>
<tr><td></td><td>4</td><td></td></tr>
</table>

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4(b) | $\bar{x} = \frac{1}{2}d$ | **B1FT** | SOI, equate *their* $\bar{x}$ to $\frac{1}{2}d$. |
| | $k^2h^2 - 2dh - 6d^2 [= 0]$ | **M1** | Rearrange to obtain a 3-term quadratic in $h$ of the form $\alpha k^2h^2 + \beta dh + \gamma d^2 [= 0]$. Allow, for example, an equation of the form $k^2h^2 - 2dh = 6d^2$.<br>*Their* $\bar{x}$ must be of the form $\frac{kh(\alpha d + \beta kh)}{(\gamma hk + \delta h + \epsilon d)}$, where $\alpha, \beta, \gamma, \delta, \epsilon$ are all non-zero constants |
| | $h = \frac{d + d\sqrt{1+6k^2}}{k^2} \left[ = \frac{d}{k^2}\left(1 + \sqrt{1+6k^2}\right) \right]$ | **A1** | OE, for example, $h = \frac{2d + \sqrt{4d^2 + 24k^2d^2}}{2k^2}$.<br>If seen, must reject $\frac{d}{k^2}\left(1 - \sqrt{1+6k^2}\right)$. |
| | | **3** | |
| 4(c) | $1.5d = \frac{d}{k^2}\left(1 + \sqrt{1+6k^2}\right)$ | **M1** | **Dependent on M1 in 4(b).**<br>Equating *their* $h$ to $1.5d$ or substituting $h = 1.5d$ into $k^2h^2 - 2dh - 6d^2 = 0$. |
| | $k = 2$ only | **A1** | If seen, $k = 0$ and $k = -2$ must be rejected. |
| | | **2** | |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 5(a) | $\frac{3}{5}u_A = \frac{4}{5}v_A$ | ***B1** | Velocity perpendicular to line of centres.<br>Substitute values of $\sin\alpha$ and $\sin\theta$.<br>OE, for example, $3u_A = 4v_A$. |
| | $\left[\frac{\frac{1}{2}mu_A{}^2 - \frac{1}{2}m\left(\frac{3}{4}u_A\right)^2}{\frac{1}{2}mu_A{}^2} \times 100 = \right] 43.75\,(\%)$ | **DB1** | Calculate the percentage loss in KE of $A$.<br>OE, for example, $\frac{175}{4}$.<br>Condone 43.8. |
| | | **2** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 5(b) | $\frac{7}{25}u_B = \frac{3}{5}v_B \quad [7u_B = 15v_B]$ | **B1** | Velocity perpendicular to line of centres.<br>Values for trigonometric functions must be substituted. |
| | $mu_A\cos\alpha - mu_B\cos\beta = -mv_A\cos\theta + mv_B\cos\varphi$<br>leading to<br>$m\left(\frac{4}{5}u_A\right) - m\left(\frac{24}{25}u_B\right) = -mv_A \times \frac{3}{5} + mv_B \times \frac{4}{5}$. | **M1** | Dimensionally correct momentum equation ($m$ required).<br>Allow sin/cos mix only.<br>Values for trigonometric functions must be substituted.<br>Allow 37 or better (36.8698…) for $\alpha, \varphi$.<br>Allow 16 or better (16.2602…) for $\beta$.<br>Allow 53 or better (53.131…) for $\theta$.<br>OE, for example,<br>$m\left(\frac{4}{5}u_A\right) - m\left(\frac{24}{25}u_B\right) = -m\left(\frac{3}{4}u_A\right) \times \frac{3}{5} + m\left(\frac{7}{15}u_B\right) \times \frac{4}{5}$.<br>May be implied by $15u_A = 16u_B$, $7v_A = 12v_B$. |
| | $e\left(u_A\cos\alpha + u_B\cos\beta\right) = v_A\cos\theta + v_B\cos\varphi$<br>leading to<br>$e\left(\frac{4}{5}u_A + \frac{24}{25}u_B\right) = \frac{3}{5}v_A + \frac{4}{5}v_B$ | **M1** | Use Newton's experimental law to form an equation.<br>Allow sin/cos mix only.<br>Values for trigonometric functions must be substituted.<br>Allow 37 or better (36.8698…) for $\alpha, \varphi$.<br>Allow 16 or better (16.2602…) for $\beta$.<br>Allow 53 or better (53.131…) for $\theta$.<br>Signs for approach velocities must be consistent with those for velocities before the collision in momentum equation.<br>OE, for example, $e\left(\frac{4}{5}u_A + \frac{24}{25}u_B\right) = \frac{9}{20}u_A + \frac{28}{75}u_B$. |
| | $e = \frac{8}{17}[= 0.471]$ | **A1** | Substitute expressions for $u_A$, $v_A$, $u_B$, $v_B$ and simplify.<br>$e = -\frac{88}{263}[= -0.335]$ from correct working **B1M1M1A0**. |
| | | **4** | |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6(a) | $T = \dfrac{1.6mgx}{10a}$ | **B1** | Correct use of Hooke's law. |
| | $T = 0.2mg \times \frac{4}{5}\left[= 0.16mg\right]$ | **M1** | Use of N2L, must be considering same mass on both sides.<br>Allow sin/cos mix. Allow sign error.<br>Must replace $\sin\theta$ with a numerical value. |
| | $0.16mg = \dfrac{1.6mgx}{10a}$<br>$x = a$<br>$OP = 10a - a = 9a$. | **A1** | **AG**, set up correct equation and find length. |
| | | **3** | |
| 6(b) | $\frac{1}{2} \times 0.3mv^2 = 10a \times \frac{4}{5} \times 0.3mg$<br><br>OR<br><br>$v^2 = 2 \times 10a \times g \times \frac{4}{5}$ | ***M1** | Energy equation before collision.<br>Same mass on both sides (allow $m$ instead of $0.3m$).<br>Correct number of terms, dimensionally correct.<br>Substitute value for $\sin\theta$ (may be done after $m$ cancelled).<br>Allow sin/cos mix.<br>OR<br>Use kinematics to find an equation containing $v$, $a$ and $g$, including substituting value for $\sin\theta$. Allow sin/cos mix. |
| | $v = 4\sqrt{ag}$ | **A1** | Award **A1** for $v^2 = 16ag$. |
| | $0.3m \times '4\sqrt{ag}' = (0.3m + 0.2m)w$ | **DM1** | Dimensionally correct momentum equation, masses must be present, with *their v* substituted. |
| | $w = 2.4\sqrt{ag}$ | **A1** | OE, for example, $\dfrac{1.2}{0.5}\sqrt{a}\sqrt{g}$.<br>**SC B1 for correct answer if *m* is missing throughout.** |
| | | **4** | |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6(c) | $x$ defined as the distance from $O$ (2 GPE terms):<br>$\frac{1}{2}\times 0.5m\times "2.4^2 ag"+0.5mg\times 9a\times\frac{4}{5}+\frac{1.6mga^2}{20a}=0.5mg\times x\times\frac{4}{5}+\frac{1.6mg(10a-x)^2}{20a}$<br>OR<br>$x$ defined as the final extension (2 GPE terms):<br>$\frac{1}{2}\times 0.5m\times "2.4^2 ag"+0.5mg\times(x-a)\times\frac{4}{5}+\frac{1.6mga^2}{20a}=\frac{1.6mgx^2}{20a}$<br>OR<br>$x$ defined as the change in extension (one GPE term):<br>$\frac{1}{2}\times 0.5m\times "2.4^2 ag"+0.5mgx\times\frac{4}{5}+\frac{1.6mga^2}{20a}=\frac{1.6mg(x+a)^2}{20a}$ | **B1** | At least one correct EPE. |
| | | **M1** | Dimensionally correct energy equation with 2 EPE terms, one KE term and one/two GPE term(s) depending on how $x$ is defined.<br>Allow sign errors. Allow sin/cos mix.<br>Values for trigonometric functions must be substituted.<br>Allow slips in the EPE terms but must be of the form $k_1x^2$.<br>Do not allow sign errors in the EPE terms.<br>Mass of particle needs to be present.<br><br>Simplified equations for reference:<br>$\frac{36}{25}mag+\frac{2}{5}mg(9a-x)+\frac{2mga^2}{25a}=\frac{2mg(10a-x)^2}{25a}$<br>OR<br>$\frac{36}{25}mag+\frac{2}{5}mg(x-a)+\frac{2mga^2}{25a}=\frac{2mgx^2}{25a}$<br>OR<br>$\frac{36}{25}mag+\frac{2}{5}mgx+\frac{2mga^2}{25a}=\frac{2mg(x+a)^2}{25a}$ |
| | | **A1FT** | All terms correct. FT *their* $w^2$. |
| | $[x=]3a$ | **A1** | If seen, must reject alternative solutions outside [0, 10$a$]. |
| | | **4** | |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(a) | $V_y = u_P \sin\alpha - gt$, and so $V_y = 25\times\sin\alpha - 10t$.<br><br>At impact, $V_y = 0$, hence, $25\times\frac{4}{5} - 10t = 0$, $t = 2$. | **B1** | **AG**, minimum working $25\times\frac{4}{5} - 10t = 0$ OR $\frac{25\times\frac{4}{5}}{g} = \frac{20}{10}$.<br>**B0** if $20 - 10t = 0$ alone with no previous working shown.<br>**B0** if not using $g = 10$. |
| | | **1** | |
| 7(b) | $h = 20\times 2 - \frac{1}{2}g\times 2^2$ | ***M1** | Use $s = ut + \frac{1}{2}at^2$ to find $h$.<br>Substitute $t = 2$, $u = 25\times\frac{4}{5}$ or $25\times\frac{3}{5}$ and $a = \pm g$.<br>May see $h = 25\times\frac{4}{5}\times 2 \pm \frac{1}{2}g\times 2^2$ or $h = 25\times\frac{3}{5}\times 2 \pm \frac{1}{2}g\times 2^2$ or $0 = 20^2 - 2gh$ or $h = \frac{20}{2}\times 2$.<br>Must be clear that $h = 20$ is the maximum height. |
| | $25t_Q - \frac{1}{2}g\times t_Q{}^2 = '20'$ | **DM1** | Use $s = ut + \frac{1}{2}at^2$ to find the time $Q$ takes to get to $h$.<br>Substitute $u = 25$ and $a = \pm g$.<br>Allow *their h*.<br>This line fully correct implies **M1M1**. |
| | $t_Q = 1$, $T = 2 - t_Q = 1$ | **A1** | Exclude $t_Q = 4$.<br>Must distinguish between $T$ and $t_Q$ (for example, $t = 1$, $T = 1$ earns **A1**). |
| | | **3** | |

© Cambridge University Press & Assessment 2026

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(c) | $v\cos\theta = u_P \cos\alpha \left[=15\right]$<br>leading to<br>$v\sin\theta = \dfrac{15}{\cos\theta} \times \sin\theta$ | *M1 | Use the fact that horizontal component of the velocity is unchanged, meaning $v\cos\theta = 15$, to find the vertical component of the velocity of $P$ after the collision, $V_y$ .<br>Implied by $V_y = 15\tan\theta$ . |
| | $\left[0 = (v\sin\theta)^2 - 2g \times y_{max}\right]$<br>$0 = \left(\dfrac{15}{\cos\theta}\sin\theta\right)^2 - 2g \times y_{max}$ | DM1 | Use $v^2 = u^2 + 2as$ .<br>Substitute *their* $V_y$ and $a = \pm g$ with vertical component of velocity at maximum height set to 0 to find $h$. |
| | $y_{max} = \frac{45}{4}\tan^2\theta$ | A1 | |
| | Greatest height above ground $= 20 + \frac{45}{4}\tan^2\theta$ | A1 | OE, for example, $20 + 11.25\tan^2\theta$ . |
| | | 4 | |

© Cambridge University Press & Assessment 2026