

Mark Scheme (Results)

January 2014

Pearson Edexcel International
Advanced Level

Mechanics 2 (WME02/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

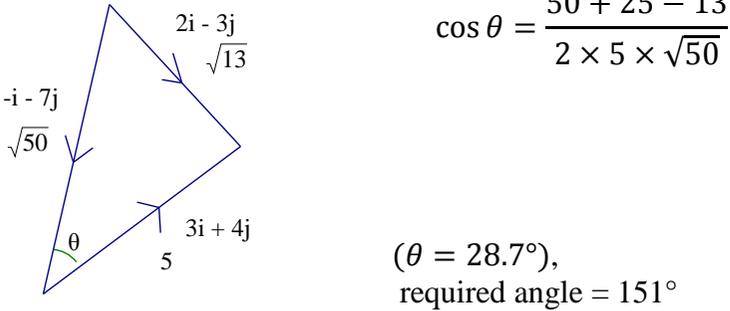
1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
 - **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)
 - Marks should not be subdivided.
3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
 - ft – follow through
 - the symbol \checkmark will be used for correct ft
 - cao – correct answer only
 - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
 - isw – ignore subsequent working
 - awrt – answers which round to
 - SC: special case
 - oe – or equivalent (and appropriate)
 - dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper
 - \square The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
 6. If a candidate makes more than one attempt at any question:
 - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
 7. Ignore wrong working or incorrect statements following a correct answer.

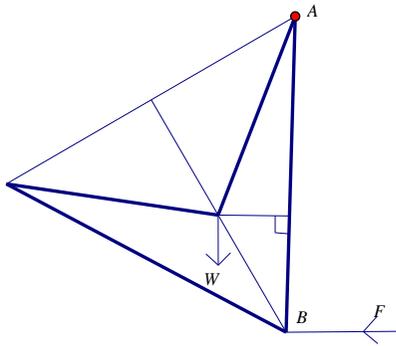
General Notes From Chief Examiner

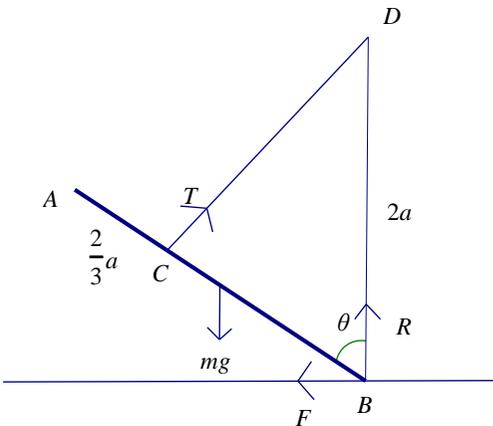
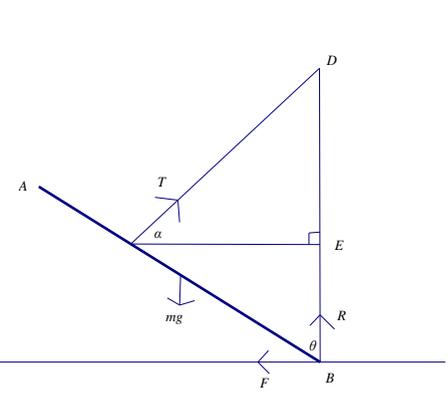
- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is accuracy error not method error.
- Omission of mass from a resolution is method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),.....then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

| Question Number | Scheme | Marks | |
|-----------------|---|------------------------------------|--|
| 1a | $2((2\mathbf{i} - 3\mathbf{j}) - (3\mathbf{i} + 4\mathbf{j})) = \mathbf{I}$ $= -2\mathbf{i} - 14\mathbf{j}$ $ \mathbf{I} = \sqrt{2^2 + 14^2} = \sqrt{200} = 10\sqrt{2} \text{ (Nm)}$ | M1 A1 A1 M1 A1 [5] | Use of impulse = change in momentum Must be subtracting Correctly substituted Use of Pythagoras for their impulse in the form $a\mathbf{i} + b\mathbf{j}$ $\sqrt{200}$, $10\sqrt{2}$, 14.1 or better |
| 1b |  | M1 A1 A1 [3] | Use of cosine rule in a triangle correct for their I . (all momentum or all velocity/speed) Correct unsimplified expression for $\cos \theta$ Or better |
| Alt 1b | $\cos \theta = \frac{-3-28}{5 \times \sqrt{50}}$ $\theta = 151^\circ$ | M1 A1 A1 [3] | Correct use of scalar product (for their I) Correct unsimplified expression for $\cos \theta$. NB scalar product of I and u is OK Or better |
| Alt 1b | $\tan^{-1} \frac{4}{3} + \tan^{-1} \left(\text{their } \frac{2}{14} \right) + 90 \text{ or equivalent}$ $\theta = 151^\circ$ | M1 A1 A1 [3] [8] | Correct strategy Correct unsimplified Or better |

| Question Number | Scheme | Marks | |
|-----------------|--|---------------------------------------|--|
| 2a | $v = 3t^2 - 16t + 20 \Rightarrow a = 6t - 16$ $t = 3, a = 18 - 16 = 2 \text{ (ms}^{-2}\text{)}$ | M1 A1 A1 [3] | Differentiation of v (having multiplied out). Need evidence of correct method but condone a slip. Correct differentiation of their 3 term quadratic cso |
| 2b | $s = \int 3t^2 - 16t + 20 dt = t^3 - 8t^2 + 20t (+C)$ $t = 0, s = 0$ $t = 2, s = 8 - 32 + 40 = 16$ $t = 3, s = 27 - 72 + 60 = 15$ Distance = $16 + 1 = 17$ (m) | M1 A2 M1 A1 A1 [6] | Integration of v cao Condone missing C . -1 each error Strategy for total distance - needs to include use of $t = 2$ Correct unsimplified cao |
| 2c | $s = 0 \Rightarrow t^3 - 8t^2 + 20t = 0$ $t \neq 0 \Rightarrow t^2 - 8t + 20 = 0$ $(t - 4)^2 + 4 \geq 4 \forall t, \text{ (or } > 0) \text{ so no solutions, so } s \text{ is never zero again}$ | M1 A1 [2] | Set $s = 0$ and solve for t Or equivalent argument for $s \neq 0$ |
| Alt 2c | $t = \frac{10}{3}, s = 14.8$ $t > \frac{10}{3}, v > 0 \text{ so } s \text{ never decreases again - no return}$ | M1 A1 [2] [11] | Consider s when P stops going towards O |

| Question Number | Scheme | Marks | |
|-----------------|--|---|--|
| 3a | Horizontal: max speed \Rightarrow Driving force = R Use of $P = Fv$ $P = 30R$ On the slope: $F = mg \sin \theta + R \left(= \frac{550g}{14} + R \right)$ $P = 25 \left(\frac{550g}{14} + R \right) = 25(385 + R)$ $30R = 25R + 385 \times 25 = 25R + 9625$ or $P = 25 \left(385 + \frac{P}{30} \right)$ $R = 1900 \text{ (1930) N} \quad P = 58\,000 \text{ (57\,800) W}$ | B1 B1 M1 A1 DM1 DM1 A2 [8] | Resolve to find driving force parallel to the slope. Condone sign and sin/cos confusion. Correct unsimplified equation Use of $P = Fv$ Use simultaneous equations to form an equation in P or R A1 for each one correct to 2 or 3 s.f. Lose first A1 for one or both overspecified. |
| 3b | At 20 m s^{-1} , $\frac{50,000}{20} - R = 550a$ $\frac{50000}{20} - 1925 = 550a$ Acceleration = $1.0 \text{ (1.05) m s}^{-2}$ | M1 A1 DM1 A1 [4] [12] | Use of $F = ma$ and $P = Fv$ Correct equation (with or without substitution for R) Substitute for their R and solve for a . Max 3 s.f. (Not $\frac{23}{22}$ unless over-accuracy already penalised) |

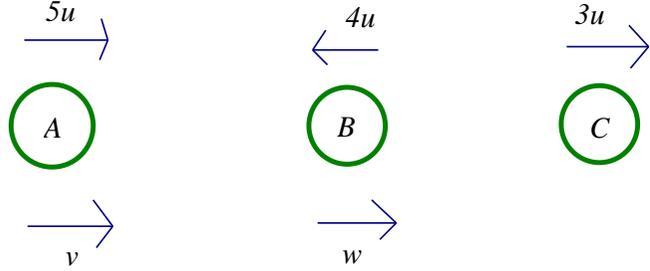
| Question Number | Scheme | Marks | | | | | | | | | | | | | | | | | | | | | |
|---|---|--|---|------|------|------------------------------------|------|------------------|------------------|-----------------------|---------------|---|---|--|-------------------|--|--|------------------------------|---|---------------|----------|-------------------------------|--------------------------------|
| <p>4a</p> <table border="1" data-bbox="432 172 1198 379"> <tr> <td></td> <td>ABC</td> <td>ACD</td> <td>ABCE</td> </tr> <tr> <td>Area</td> <td>$2 \times 2\sqrt{3} (= 4\sqrt{3})$</td> <td>$2h$</td> <td>$4\sqrt{3} - 2h$</td> </tr> <tr> <td>c of m from base</td> <td>$\frac{2\sqrt{3}}{3}$</td> <td>$\frac{h}{3}$</td> <td>h</td> </tr> </table> $4\sqrt{3} \times \frac{2\sqrt{3}}{3} - 2h \times \frac{h}{3} = h(4\sqrt{3} - 2h)$ $8 - \frac{2}{3}h^2 = 4\sqrt{3}h - 2h^2$ $h^2 - 3\sqrt{3}h + 6 = 0$ $h = \frac{3\sqrt{3} \pm \sqrt{27 - 24}}{2} = \frac{2\sqrt{3}}{2} = \sqrt{3} \text{ (m)}$ | | ABC | ACD | ABCE | Area | $2 \times 2\sqrt{3} (= 4\sqrt{3})$ | $2h$ | $4\sqrt{3} - 2h$ | c of m from base | $\frac{2\sqrt{3}}{3}$ | $\frac{h}{3}$ | h | <table border="1" data-bbox="846 587 1120 821"> <tr> <td>$(\sqrt{3})^2 - 3\sqrt{3}\sqrt{3} + 6$</td> </tr> <tr> <td>$= 3 - 9 + 6 = 0$</td> </tr> </table> | $(\sqrt{3})^2 - 3\sqrt{3}\sqrt{3} + 6$ | $= 3 - 9 + 6 = 0$ | <p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>[7]</p> | <p>Correct area ratios</p> <p>Correct distances</p> <p>Moments about AC or an axis parallel to AC. Needs to include all relevant terms.</p> <p>Correct unsimplified equation</p> <table border="1" data-bbox="1377 587 1960 821"> <tr> <td>Simplify to 3 term quadratic</td> <td>Substitute $h = \sqrt{3}$ in their equation</td> </tr> <tr> <td>Solve for h</td> <td>Simplify</td> </tr> <tr> <td>Obtain given answer correctly</td> <td>Confirm given result correctly</td> </tr> </table> | Simplify to 3 term quadratic | Substitute $h = \sqrt{3}$ in their equation | Solve for h | Simplify | Obtain given answer correctly | Confirm given result correctly |
| | ABC | ACD | ABCE | | | | | | | | | | | | | | | | | | | | |
| Area | $2 \times 2\sqrt{3} (= 4\sqrt{3})$ | $2h$ | $4\sqrt{3} - 2h$ | | | | | | | | | | | | | | | | | | | | |
| c of m from base | $\frac{2\sqrt{3}}{3}$ | $\frac{h}{3}$ | h | | | | | | | | | | | | | | | | | | | | |
| $(\sqrt{3})^2 - 3\sqrt{3}\sqrt{3} + 6$ | | | | | | | | | | | | | | | | | | | | | | | |
| $= 3 - 9 + 6 = 0$ | | | | | | | | | | | | | | | | | | | | | | | |
| Simplify to 3 term quadratic | Substitute $h = \sqrt{3}$ in their equation | | | | | | | | | | | | | | | | | | | | | | |
| Solve for h | Simplify | | | | | | | | | | | | | | | | | | | | | | |
| Obtain given answer correctly | Confirm given result correctly | | | | | | | | | | | | | | | | | | | | | | |
| <p>4b</p>  $F \times 4 = W \times (2\sqrt{3} - \sqrt{3}) \times \sin 30$ $= W \times \frac{\sqrt{3}}{2}$ $F = \frac{\sqrt{3}W}{8}$ | | <p>M1</p> <p>A1</p> <p>A1</p> <p>A1</p> <p>[4]</p> <p>[11]</p> | <p>Taking moments about A.</p> <p>$4F = W \times d$ with d indicated correctly on diagram</p> <p>Equation with d correct</p> <p>($F \times 4 = W \times \sqrt{7} \sin 19.1$)</p> <p>Accept $F = 0.22W$ or better</p> | | | | | | | | | | | | | | | | | | | | |

| Question Number | Scheme | Marks | |
|-----------------|---|--|--|
| 5a |  $mg \times a \sin \theta = F \times 2a$ $F = \frac{mg \sin \theta}{2}$ | M1 A1 A1 [3] | Moments about D . Condone sin/cos confusion. The Q tells them to use D but accept complete alternative routes to the given answer. Correct unsimplified equation *Given Answer* |
| 5b | $mg \times \frac{a}{3} \sin \theta + F \times \frac{4a}{3} \cos \theta = R \times \frac{4a}{3} \sin \theta$ $mg(1 + 2 \cos \theta) = 4R, \quad R = \frac{mg(1 + 2 \cos \theta)}{4}$ | M1 A2 DM1 A1 [5] | Moments about C . Need all three terms. Condone sin/cos confusion and sign errors. -1each error Substitute for F and find R |
| 5b alt |  | M1 A1 A1 M1 A1 [5] | Resolve vertically or horizontally $T \cos \alpha = F$ $T \sin \alpha + R = mg$ $R = mg - \frac{mg \sin \theta \sin \alpha}{2 \cos \alpha}$ Link α and θ : $\tan \alpha = \frac{DE}{CE} = \frac{2a - \frac{4}{3}a \cos \theta}{\frac{4}{3}a \sin \theta}$ $R = mg - mg \sin \theta \frac{2a - (4/3)a \cos \theta}{2 \times (4/3)a \sin \theta} \left(= \frac{mg}{4} (1 + 2 \cos \theta) \right)$ |

| Question Number | Scheme | Marks | |
|-----------------|---|--------------------------------|--|
| 5c | Use of $F = \mu R$ Use of $\sin \theta = \frac{4}{5}$ and $\cos \theta = \frac{3}{5}$ $\mu = \frac{\frac{mg \sin \theta}{2}}{\frac{mg(1+2 \cos \theta)}{4}} = \frac{2 \sin \theta}{1+2 \cos \theta} = \frac{8}{11}$ | M1 DM1 A1 [3] [11] | Substitute trig values. Dependent on the preceding M mark 0.73 or better |

| Question Number | Scheme | Marks | |
|-----------------|---|--|--|
| 6a | Velocity after t seconds = $3\mathbf{i} + (v - gt)\mathbf{j}$ KE $9 + v^2 = 2(9 + (v - gt)^2)$ $9 + v^2 = 18 + 2v^2 - 12v + 18$ $v^2 - 12v + 27 = 0$ $(v - 3)(v - 9) = 0, \quad v = 9$ | B1 B1 M1 A2 A1 DM1 A1 [8] | Horizontal component Vertical component Both B marks could be implied in the KE equation KE equation condone 2 on the wrong side Correct unsimplified equation. -1 each error Correct equation in v Solve for v only |
| 6a alt | $s_y = v \times \frac{15}{49} - \frac{g}{2} \left(\frac{15}{49} \right)^2$ $\frac{1}{2} \times \frac{1}{2} (9 + v^2) = g \left(\frac{15v}{49} - 4.9 \left(\frac{15}{49} \right)^2 \right)$ $v^2 - 12v + 27 = 0$ $(v - 3)(v - 9) = 0, \quad v = 9$ | B2 M1 A2 A1 DM1 A1 [8] | Vertical height when $t = \frac{15}{49}$ Allow with t -1 each error Use of GPE gained = KE lost Allow with t -1 each error. t must be substituted Correct equation in v Solve for v only |
| 6b | At B, vertical component = $-6 (= -(v - 3))$ $-6 = 9 - gt$ $t = \frac{15}{g} = \left(\frac{75}{49} \right) = 1.53 \quad (1.5)$ | B1 M1 A1 [3] | Allow for their v for their v Correct only |
| 6b alt | Time to top = $\frac{9}{g}$ Time to same height = $\frac{9}{g} + \left(\frac{9}{g} - \frac{15}{49} \right)$ $t = 1.53$ | B1 M1 A1 [3] | Or time to ground and work back |

| Question Number | Scheme | Marks | |
|-----------------|--|--------------------------------------|--|
| 6b alt | Height at A is $\frac{225}{98}$ $\frac{225}{98} = 9t - \frac{1}{2}gt^2$ $t = 1.53$ | B1 M1 A1 [3] [11] | Use <i>suvat</i> for vertical distance |

| Question Number | Scheme | Marks | |
|-----------------|--|---|---|
| 7a |  <p>CLM: $5mu - 4mu = mv + mw$ ($u = v + w$)</p> <p>NEL: $w - v = 9ue$</p> <p>$2w = 9eu + u, \quad w = \frac{u}{2}(9e + 1)$</p> <p>$2v = u - 9eu, \quad v = \left \frac{u}{2}(1 - 9e) \right$</p> | <p>M1 A1 M1 A1 DM1 A1 A1</p> <p>(7)</p> | <p>Needs all the terms. Condone sign errors</p> <p>Impact law - condone sign errors but must be used the right way round.</p> <p>Solve for v or w. Dependent on both of the preceding M marks</p> <p>The Q asks for speed, so need the modulus.</p> |
| 7b | <p>B cannot catch C: $w \leq 3u \Rightarrow 9eu + u \leq 6u, \quad e \leq \frac{5}{9}$</p> <p>Direction of A reversed: $v < 0 \Rightarrow 1 - 9e < 0, \quad e > \frac{1}{9}$</p> <p>$\frac{1}{9} < e \leq \frac{5}{9}$</p> | <p>M1 A1 M1 A1</p> <p>(4) [11]</p> | <p>A correct inequality (condone strict inequality $w < 3u$)</p> <p>A correct critical value $\frac{5}{9}$ or $\frac{1}{9}$</p> <p>Second inequality correct</p> <p>cao</p> |

