Version 1.0: 0109

## General Certificate of Education

# Mathematics 6360

## MM1B Mechanics 1B

# Mark Scheme

*2009 examination - January series*

*Final*

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.



Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX *Dr Michael Cresswell Director General*

**Key to mark scheme and abbreviations used in marking**

| | | | |
|---|---|---|---|
| M | mark is for method | | |
| m or dM | mark is dependent on one or more M marks and is for method | | |
| A | mark is dependent on M or m marks and is for accuracy | | |
| B | mark is independent of M or m marks and is for method and accuracy | | |
| E | mark is for explanation | | |
| | | | |
| √or ft or F | follow through from previous incorrect result | MC | mis-copy |
| CAO | correct answer only | MR | mis-read |
| CSO | correct solution only | RA | required accuracy |
| AWFW | anything which falls within | FW | further work |
| AWRT | anything which rounds to | ISW | ignore subsequent work |
| ACF | any correct form | FIW | from incorrect work |
| AG | answer given | BOD | given benefit of doubt |
| SC | special case | WR | work replaced by candidate |
| OE | or equivalent | FB | formulae book |
| A2,1 | 2 or 1 (or 0) accuracy marks | NOS | not on scheme |
| –*x* EE | deduct *x* marks for each error | G | graph |
| NMS | no method shown | c | candidate |
| PI | possibly implied | sf | significant figure(s) |
| SCA | substantially correct approach | dp | decimal place(s) |

**No Method Shown**

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

**Otherwise we require evidence of a correct method for any marks to be awarded.**

**MM1B**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **1** | $2.5\times12+1.5\times4=4v$ | M1 | | M1: Three term momentum equation, correct values but condone incorrect signs. |
| | | A1 | | A1: Correct equation with correct signs. |
| | $v=\frac{36}{4}=9$ ms$^{-1}$ | A1 | 3 | A1: Correct speed<br>Note: Consistent use of *mg* instead of *m* throughout deduct 1 mark. |
| | **Total** | | **3** | |
| **2 (a)** | $t=0,\ \ t=30,\ \ t=50$ seconds | B1 | | B1: Any one correct time |
| | | B1 | 2 | B1: The other two correct times<br>Deduct one mark for each extra time if more than three times are given.<br>(eg 0, 15, 30, 50 scores B1B0)<br>(eg 0, 15, 30, 40, 50 scores B0B0)<br>Condone 49 or 48 instead of 50 |
| **(b)** | $s_1=\frac{1}{2}\times30\times5=75$ m **AG** | M1 | | M1: Finding distance by calculation of area. (Must see use of 0.5 or ½) |
| | | A1 | 2 | A1: Correct answer from correct working.<br>(If candidates use two constant acceleration equations, both must be seen for the M1 mark.) |
| **(c)** | $s_2=\frac{1}{2}\times4\times20=40$ m | M1 | | M1: Finding distance using area of the second triangle. |
| | | A1 | | A1: Correct distance (ignore any negative signs).<br>(If candidates use two constant acceleration equations, both must be seen for the M1 mark.)<br>Accept 38/36 from use of 49/48 instead of 50 |
| | $s=75+40=115$ m | M1 | | M1: Addition of the 75 metres and their distance. (75 – 40 = 35 OE scores M0) |
| | | A1F | 4 | A1F: Correct result using their value for second area.<br>eg Accept 113/111 from use of 49/48 instead of 50 |
| **(d)** | $s=75-40=35$ m | M1 | | M1: Difference between 75 and their value for the second distance. (Allow their distance – 75)<br>(75 – (– 40) = 115 OE scores M0) |
| | | A1F | 2 | A1F: Correct result using their value for second area.<br>(eg 40 – 75 = –35 M1A0)<br>eg Accept 37/39 from use of 49/48 instead of 50 |
| | **Total** | | **10** | |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **3(a)** | $4a = 4g\sin 40°$ | M1 | | M1: Resolving and application of Newton's second law. Allow cos40°. |
| | | A1 | | A1: Correct expression. |
| | $a = g\sin 40° = 6.30 \text{ ms}^{-2}$ **AG** | A1 | 3 | A1: Correct result from correct working. Must see 6.30 not 6.3. Just seeing $g\sin 40° = 6.30 \text{ ms}^{-2}$ scores full marks. Use of $g$ = 9.81 gives 6.31, M1A1A0, but don't penalise again on the same script. |
| **(b)** | $0.9 = 0 + \frac{1}{2}\times a \times 0.6^2$ | M1 | | M1: Use of a constant acceleration equation to find $a$, with $s$ =0.9, $u$ =0 and $t$ = 0.6. |
| | | A1 | | A1: Correct equation |
| | $a = \frac{0.9\times 2}{0.6^2} = 5 \text{ ms}^{-2}$ | A1 | | A1: Correct acceleration |
| | **ALT Method** | | | |
| | $0.9 = \frac{1}{2}(\ 0 + v\ )\times 0.6$ | | | |
| | $v = 3$ | | | No marks at this stage. |
| | $3 = 0 + 0.6a$ | (M1A1) | | M1: Constant acceleration equation with $u$ = 0 and $t$ = 0.6. |
| | | (A1) | 3 | A1: Correct equation |
| | $a = 5 \text{ ms}^{-2}$ | | | A1: Correct acceleration. |
| **(c)** | The acceleration is reduced because of air resistance or the fact that there is friction. | B1 | 1 | B1: Must mention air resistance/resistive forces or friction. Do not allow air friction. |
| | **Total** | | **7** | |

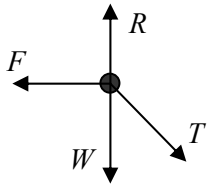
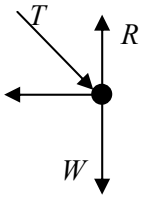
**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **4(a)** | Peg is smooth | B1 | 1 | B1: Correct assumption |
| **(b)** | String is light | B1 | | B1: First correct assumption |
| | String is inextensible or inelastic<br>Tension is the same throughout the string | B1 | 2 | B1: Second correct assumption<br>Note: Ignore any additional assumptions. |
| **(c)** | $11g - T = 11a$ | M1 | | M1: Equation of motion for $A$, containing $T$, 11g or 107.8 and $11a$. |
| | | A1 | | A1: Correct equation |
| | $T - 9g = 9a$ | M1 | | M1: Equation of motion for $B$ containing $T$, $9g$ or 88.2 and $9a$. |
| | | A1 | | A1: Correct equation |
| | $2g = 20a$<br>$a = 0.98$ ms$^{-2}$ **AG** | A1 | 5 | A1: Correct acceleration from correct working.<br><br>Note: Do not penalise candidates who consistently use signs in the opposite direction throughout, provided they give their final answer as 0.98. If final answer is – 0.98 don't award final A1 mark.<br><br>**Special Case:**<br>Whole String Method $2g = 20a$ and $a = 2g / 20 = 0.98$ OE M1A1A1<br><br>Use of $g = 9.81$ gives 0.981. If this is the first time award M1A1M1A1A0, but don't penalise again on the same script. |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **4(d)(i)** | $v = 0 + 0.98 \times 0.5 = 0.49$ ms$^{-1}$ | M1<br><br>A1 | <br><br>2 | M1: Use of constant acceleration equation to find $v$ with $u = 0$, $a = 0.98$ and $t = 0.5$.<br>A1: Correct $v$ |
| **(d)(ii)** | $s = 0 + \frac{1}{2} \times 0.98 \times 0.5^2 = 0.1225$ m<br><br>**OR**<br>$0.49^2 = 0^2 + 2 \times 0.98s$<br>$s = \frac{0.49^2}{2 \times 0.98} = 0.1225$<br><br>$d = 2 \times 0.1225$<br>$= 0.245$ m | M1<br><br>A1<br><br>(M1)<br><br>(A1)<br><br>M1<br><br>A1 | <br><br><br><br><br><br><br>4 | M1: Finding distance travelled by each particle with $u = 0$, $a = 0.98$ and $t = 0.5$.<br>A1: Correct distance. Accept 0.122 or 0.123<br><br>M1: Finding distance travelled by each particle with $u = 0$, $a = 0.98$ and their $v$.<br>A1: Correct distance. Accept 0.122 or 0.123<br>M1: Doubling distance or use of $d/2$ in their original equation.<br>A1: Correct final distance. Allow 0.244 or 0.246.<br>(Use of $0.5 \times 0.49 = 0.245$ scores zero unless justified) |
| | | | | **If candidates calculate the distance first award marks as above (see (d)(i)) or:**<br>M1: Use of constant acceleration equation to find $v$ with $u = 0$, $a = 0.98$ and $s = 0.1225$.<br>A1: Correct $v$<br>**Note: If parts (i) and (ii) are not separated or clearly labelled still award marks for both parts if justified.** |
| | **Total** | | **14** | |

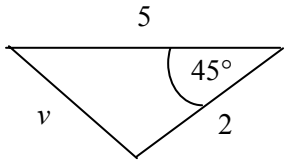
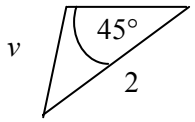
**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **5(a)** |  | B1 | 1 | B1: Diagram with four forces showing arrow heads and labelled.<br>Allow *mg* or 8*g*.<br>Allow *T* or 40 or other reasonable notation.<br>Allow $\mu R$.<br>Direction of friction must be to the left.<br><br>Any components must be shown in a different style. |
| | **OR**<br>  | | | |
| **(b)** | $8g + 40\sin 30° (= R)$ | M1 | | M1: Expression for normal reaction, with *mg* or 8*g* and 40sin30° or 40cos30°.<br>Allow incorrect signs. |
| | | A1 | | A1: Correct expression with correct signs. |
| | $(R =) 98.4$ N **AG** | A1 | 3 | A1: Correct value from correct working.<br>Use of $g = 9.81$ gives 98.5 N. Do not penalise if you have already done so earlier in the script. Otherwise penalise by 1 mark. |
| **(c)** | $F = 40\cos 30° = 34.6$ N | M1 | | M1: Use of 40cos30° or 40sin30°.<br>Award M0 if any extra terms. |
| | | A1 | 2 | A1: Correct value for friction. Don't need to see *F*. |
| **(d)** | $40\cos 30° \le \mu \times 98.4$ | M1 | | M1: Use of $F \le \mu R$ (or $F = \mu R$). Must use *R* = 98.4 and a positive value for *F*. |
| | | A1F | | A1F: Correct inequality or equation<br>Allow use of $F = \mu R$ throughout. |
| | $\mu \ge \dfrac{40\cos 30°}{98.4}$ | | | |
| | $\mu \ge 0.352$ | A1F | 3 | A1F: Correct minimum value. For follow through must use *R* = 98.4 and their value for *F* from part (c). For example use of sin 30° in part (c) gives 0.203. |
| | **Total** | | **9** | |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **6(a)** | Resultant $= (6\mathbf{i} - 3\mathbf{j}) + (3\mathbf{i} + 15\mathbf{j})$<br>$= 9\mathbf{i} + 12\mathbf{j}$ | M1<br>A1 | 2 | M1: Summing the two vectors<br>A1: Correct resultant |
| **(b)** | Magnitude $= \sqrt{9^2 + 12^2}$<br>$= 15$ N | M1<br>A1F | 2 | M1: Finding magnitude with an addition sign.<br>A1F: Correct magnitude based on their answer to part (a). |
| **(c)** | $1.5m = 9$ or $2m = 12$<br>$m = 6$ kg $m = 6$ kg | M1<br>A1F | 2 | M1: Applying Newton's second law to one or both of the components.<br>A1F: Correct mass, follow through their answer to part (a). Do not award this mark if vector division with 2 components has been used, eg<br>$\frac{9\mathbf{i} + 12\mathbf{j}}{1.5\mathbf{i} + 2\mathbf{j}} = 6$ or $6\mathbf{i} + 6\mathbf{j}$ etc without a correct previous statement gives M0A0 |
| **(d)(i)** | $\mathbf{r} = \frac{1}{2}(1.5\mathbf{i} + 2\mathbf{j})t^2$ | M1<br>A1 | 2 | M1: Using a constant acceleration equation to find the position vector with $\mathbf{u} = 0\mathbf{i} + 0\mathbf{j}$<br>A1: Correct position vector. |
| **(d)(ii)** | $\mathbf{r} = \frac{1}{2}(1.5\mathbf{i} + 2\mathbf{j}) \times 2^2 = 3\mathbf{i} + 4\mathbf{j}$<br>$d = \sqrt{(3)^2 + (4)^2}$<br>$= \sqrt{25} = 5$ | M1<br>A1 | 2 | M1: Finding the position vector when $t = 2$ .<br>($\mathbf{r} = (1.5\mathbf{i} + 2\mathbf{j}) \times 2 = 3\mathbf{i} + 4\mathbf{j}$ scores M0 unless it is clear how the 2 was obtained, possibly by a correct formula in (d) (i))<br>A1: Correct distance |
| | **Total** | | **10** | |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **7(a)** |  | B1 | | B1: Forming a triangle or diagram to find *v*. Do not penalise if the sides are not in proportion. (See example)  |
| | Followed by | | | (may be implied later by a correct equation) |
| | $v^2 = 2^2 + 5^2 - 2\times 2\times 5\cos 45°$ | M1 | | M1: Using cosine rule with 2, 5 and any angle to find *v*. Equation must contain a negative sign and a cosine. |
| | | A1 | | A1: Correct equation. Note that the implied B1 can be awarded at this stage. |
| | $v = 3.85459 = 3.85$ ms$^{-1}$ (to 3sf) **AG** | A1 | | A1: Correct velocity from correct working with an intermediate calculation shown or a final value from a value with more than 3 sf. |
| | **OR** | | | |
| | $v_1 = 5 - 2\cos 45°$ (= 3.5858) | (M1) | | M1: Two perpendicular equations, with 2, 5 and sin45° or cos45°. |
| | $v_2 = 2\cos 45°$ (= 1.414) | (A1) | | A1: Both components with correct magnitude. Note that the implied B1 can be awarded at this stage. |
| | $v = \sqrt{(5 - 2\cos 45°)^2 + (2\cos 45°)^2}$ | | | |
| | $v = 3.85459 = 3.85$ ms$^{-1}$ (to 3sf) **AG** | (A1) | 4 | A1: Correct velocity from correct working with an intermediate calculation shown or a final value from a value with more than 3 sf. |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **7(b)** | $\frac{\sin\theta}{2} = \frac{\sin 45°}{3.855}$ | M1 | | M1: Use of sine rule, with 2, 3.855 or 3.85 or awrt 3.85 and any angle. |
| | | A1 | | A1: Correct expression |
| | $\theta = 21.5°$ | A1 | | A1: Correct angle. Awrt 21° or 22° |
| | Bearing = 270 +21.5 = 292° | A1 | | A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291° |
| | **OR** | | | |
| | $\frac{\sin\theta}{5} = \frac{\sin 45°}{3.855}$ | (M1) | | M1: Use of sine rule, with 5, 3.855 or 3.85 or awrt 3.85 and any angle. |
| | | (A1) | | A1: Correct expression |
| | $\theta = 113°$ | (A1) | | A1: Correct angle. Allow awrt 113° or 114°. Also allow awrt 66° or 67°. |
| | Bearing = 360 – (113.3 – 45) = 292° | (A1) | | A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291° |
| | **OR** | | | |
| | $\tan\theta = \frac{2\cos 45°}{5 - 2\cos 45°}$ | (M1) | | M1: Consideration of perpendicular components using values from part (a). |
| | | (A1) | | A1: Correct expression |
| | $\theta = 21.5°$ | (A1) | | A1: Correct positive angle. Awrt 21° or 22° Also allow method leading to awrt 68° or 69° |
| | Bearing = 270 +21.5 = 292° | (A1) | | A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291° |
| | **OR** | | | |
| | $\cos\theta = \frac{3.855^2 + 5^2 - 2^2}{2\times 5\times 3.855}$ | (M1) | | M1: Use of cosine rule, with 2, 3.855 or 3.85 or awrt 3.85 and 5. |
| | | (A1) | | A1: Correct expression |
| | $\theta = 21.5°$ | (A1) | | A1: Correct angle. Awrt 21° or 22° |
| | Bearing = 270 +21.5 = 292° | (A1) | 4 | A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291° |
| | **Total** | | **8** | |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **8** | | | | If candidates have already used $g = 9.81$ do not penalise again on this question. |
| **(a)** | $0^2 = (\ 28\sin 50°\ )^2 + 2\times(-9.8)s$ | M1<br>A1 | | M1: Equation to find the max height, with $v = 0$, $u = 28\sin 50°$ or $u = 28\cos 50°$ and –9.8 or $-g$.<br>A1: Correct equation |
| | $s = \dfrac{(\ 28\sin 50°\ )^2}{2\times 9.8} = 23.5$ m | dM1<br>A1 | | dM1: Solving for the height<br>A1: Correct height. Awrt 23.5<br>Note: If using a memorised formula, either 4 marks if final answer correct, 3 marks if substituted correctly but evaluated incorrectly, otherwise zero. |
| | **OR** | | | |
| | $0 = 28\sin 50° - 9.8t$ | (M1) | | M1: Equation to find time to the max height, with $v = 0$, $u = 28\sin 50°$ or $u = 28\cos 50°$ and –9.8 or $-g$. |
| | $t = \dfrac{28\sin 50°}{9.8} = 2.1887$ | (A1) | | A1: Correct time |
| | $s = 28\sin 50°\times 2.1887 - 4.9\times 2.1887^2 = 23.5$ | (dM1)<br>(A1) | 4 | dM1: Finding the height with their time and $u = 28\sin 50°$ or $u = 28\cos 50°$ and –4.9 or $-g/2$<br>A1: Correct height. Awrt 23.5 |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **8(b)** | $2 = 28\sin 50°t - 4.9t^2$ | M1 | | M1: Quadratic equation in $t$ with a $\pm 2$, $u = 28\sin 50°$ or $u = 28\cos 50°$ and $-4.9$ or $-g/2$. |
| | | A1 | | A1: Correct terms |
| | | A1 | | A1: Correct signs for equation |
| | $0 = 4.9t^2 - 28\sin 50°t + 2$ | | | |
| | $t = 0.0953$ or $t = 4.282$ | dM1 | | dM1: Solving the quadratic equation |
| | $t = 4.282 = 4.28$ s (to 3 sf) **AG** | A1 | | A1: Correct larger time selected from two values. |
| | OR | | | |
| | | (M1) | | M1: Calculation of two times, which sum or differ to give the time of flight. |
| | $0 = 28\sin 50° - 9.8t$ | | | |
| | $t = \dfrac{28\sin 50°}{9.8} = 2.1887$ | (A1) | | A1: Correct time by equation for zero vertical component of velocity or maximum height. |
| | OR | | | |
| | $23.5 = 28\sin 50°t - 4.9t^2$ | | | |
| | $t = 2.1887$ | | | |
| | $21.5 = 4.9t^2$ | (dM1) | | dM1: Correct expression for time to fall. |
| | $t = \sqrt{\dfrac{21.5}{4.9}} = 2.0947$ | (A1) | | A1: Correct time. |
| | 2.1887 + 2.0947 = 4.2834 = 4.28 (to 3sf) **AG** | (A1) | 5 | A1: Correct time. Accept 4.29 if their answer rounds to 4.29. |

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **8(c)** | $v_x = 28\cos 50° \ (= 18.00 \text{ ms}^{-1})$ | B1 | | B1: Horizontal component, need not be evaluated. |
| | $v_y = 28\sin 50° - 9.8 \times 4.282 = -20.51 \text{ ms}^{-1}$ | M1 | | M1: Equation for vertical component with $28\sin 50°$ (or $28\cos 50°$ if sin50° used for horizontal component), $-9.8$ and awrt 4.28. |
| | | A1 | | A1: Correct vertical component. Awrt $\pm$ 20.5 |
| | $v = \sqrt{18.00^2 + 20.51^2} = 27.3 \text{ ms}^{-1}$ | dM1 | | dM1: Finding speed with a + sign inside the square root. |
| | | A1F | 5 | A1F: Correct speed. Awrt 27.3.<br><br>Intermediate values can be implied by final answer. |
| | **Total** | | **14** | |
| | **TOTAL** | | **75** | |