



**General Certificate of Education**

**Mathematics 6360**

**MM1B      Mechanics 1B**

**Mark Scheme**

*2007 examination - June series*

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### 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.**

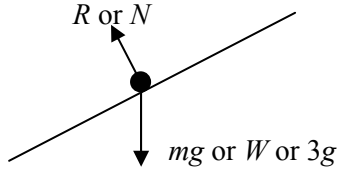
## MM1B

| Q            | Solution   | Marks | Total            | Comments  |
|--------------|--|-------|------------------|---|
| 1(a)         | $v = 0 + 1.5 \times 9.8$   | M1    | 2                | Use of constant acceleration equation to find $v$                                       |
|              | $= 14.7 \text{ ms}^{-1}$   | A1    |                  | AG Correct $v$ from correct working<br>$1.5 \times 9.8 = 14.7$ is not enough on its own |
| (b)          | $h = \frac{1}{2} \times 9.8 \times 1.5^2$  | M1    | 2                | Use of constant acceleration equation with $a = 9.8$ to find $h$                        |
|              | $= 11.0 \text{ m (to 3 sf)}$   | A1    |                  | Correct $h$<br>Allow 11 m; ignore negative signs  |
| (c)          | $5^2 = 0^2 + 2 \times 9.8s$  | M1    | 3                | Use of constant acceleration equation with $u = 0$ to find $s$                          |
|              |  | A1    |                  | Correct equation  |
|              | $s = \frac{25}{19.6} = 1.28 \text{ m (to 3 sf)}$   | A1    |                  | Correct $s$<br>Accept 1.27  |
|              | <b>OR</b><br>$t = \frac{5}{9.8} = 0.510$   |       |                  |   |
|              | $s = \frac{1}{2}(0 + 5) \frac{5}{9.8} = 1.28 \text{ m}$  |       |                  |   |
|              | <b>OR</b><br>$s = 0 + \frac{1}{2} \times 9.8 \times \left(\frac{5}{9.8}\right)^2 = 1.28 \text{ m}$             |       |                  |   |
| <b>Total</b> |  |       | <b>7</b>         |   |
| 2(a)         | $2 \begin{bmatrix} 3 \\ -2 \end{bmatrix} + 3 \begin{bmatrix} -4 \\ 1 \end{bmatrix} = 5\mathbf{v}$              | M1    | 3                | Three term vector equation, with a '+' sign, for conservation of momentum               |
|              |  | A1    |                  | Correct equation<br>Deduct this first A mark for use of $mg$                            |
|              | $\mathbf{v} = \frac{1}{5} \begin{bmatrix} -6 \\ -1 \end{bmatrix} = \begin{bmatrix} -1.2 \\ -0.2 \end{bmatrix}$ | A1    | Correct velocity |   |
| (b)          | $v = \sqrt{1.2^2 + 0.2^2} = 1.22 \text{ ms}^{-1}$  | M1    | 2                | Finding speed from their velocity in part (a)<br>(Must include addition of two terms)   |
|              |  | A1F   |                  | Correct speed from their velocity<br>Accept 1.21  |
| <b>Total</b> |  |       | <b>5</b>         |   |

## MM1B (cont)

| Q            | Solution   | Marks    | Total     | Comments   |
|--------------|--|----------|-----------|--|
| 3(a)         | $T_1 \sin 35^\circ = T_2 \sin 35^\circ$  | M1       | 2         | Resolving two forces and forming an equation, with different tensions for each string<br>Correct result from correct working   |
|              | $T_1 = T_2$<br><b>OR</b><br>$T_1 \cos 55^\circ = T_2 \cos 55^\circ$<br>$T_1 = T_2$   | A1       |           |  |
| (b)          | $T_1 \cos 35^\circ + T_2 \cos 35^\circ = 2 \times 9.8$   | M1       | 5         | Resolving forces to form a three term vertical equation<br>Correct equation<br>$T_1$ or $T_2$ eliminated correctly<br>Solving for $T_1$ or $T_2$<br>Correct tension<br>Accept 12 N or 11.9 N                               |
|              | $T_1 \cos 35^\circ + T_1 \cos 35^\circ = 2 \times 9.8$   | A1       |           |  |
|              | $T_1 = \frac{2 \times 9.8}{2 \cos 35^\circ} = 12.0 \text{ N (to 3sf)}$   | dM1      |           |  |
|              |  | A1       |           |  |
| (c)          | $2 \times 40 \cos 35^\circ = 9.8m$   | M1       | 3         | Forming an equation with two tensions to find $m$<br>Correct equation<br>Correct mass<br>Accept 6.68   |
|              | $m = \frac{80 \cos 35^\circ}{9.8} = 6.69 \text{ kg}$   | A1       |           |  |
|              | <b>OR</b>  | (M1)     |           |  |
|              | $m = \frac{40}{11.96} \times 2$  | (A1)     |           |  |
|              | $= 6.69 \text{ kg}$  | (A1)     |           |  |
| <b>Total</b> |  |          | <b>10</b> |  |
| 4(a)         | $T - 800 = 1200 \times 0.4$  | M1       | 3         | Three term equation of motion for the car<br>Correct equation<br>Correct tension<br>Treat calculation of two tensions as two methods unless one selected<br>Treat sum or difference of two tensions as an incorrect method |
|              | $T = 800 + 480$<br>$= 1280 \text{ N}$  | A1       |           |  |
|              |  | A1       |           |  |
| (b)          | $3000 - 800 - F = 4000 \times 0.4$   | M1       | 4         | Four term equation of motion (truck or both)<br>Correct terms<br>Correct signs<br>AG Correct resistance force from correct working   |
|              | $F = 3000 - 800 - 1600$  | A1       |           |  |
|              | $F = 600 \text{ N}$  | A1       |           |  |
|              | <b>OR</b><br>$3000 - 1280 - F = 2800 \times 0.4$<br>$F = 3000 - 1280 - 1120$<br>$F = 600 \text{ N}$                          |          |           |  |
| (c)          | Increase, because a greater tension would be needed so that the horizontal component would be the same as the tension above. | B1<br>B1 | 2         | Greater Reason<br>Second B1 dependent on the first B1 mark   |
| <b>Total</b> |  |          | <b>9</b>  |  |

## MM1B (cont)

| Q            | Solution  | Marks | Total     | Comments  |
|--------------|---|-------|-----------|---|
| 5(a)         | $V = 150 \tan 30^\circ$   | M1    | 2         | Using trigonometry (usually tan or sine rule) to find $V$<br>AG Correct answer from correct working<br>(Division by 2 only acceptable if $\sin 30^\circ$ or $\cos 60^\circ$ seen) |
|              | $= 86.6 \text{ ms}^{-1}$  | A1    |           |   |
| 5(b)         | <b>OR</b><br>$\frac{V}{\sin 30^\circ} = \frac{150}{\sin 60^\circ}$ AG   |       |           |   |
|              | $V = 86.6 \text{ ms}^{-1}$  |       |           |   |
|              | $\frac{150}{v} = \cos 30^\circ$   | M1    |           | Using trigonometry or Pythagoras to find $v$  |
|              | $v = \frac{150}{\cos 30^\circ} = 173 \text{ ms}^{-1}$ (to 3sf)  | A1    | 3         | Correct expression<br>Correct answer  |
| <b>Total</b> |   |       | <b>5</b>  |   |
| 6(a)(i)      |   | B1    | 1         | Correct diagram with arrows and labels  |
| (ii)         | $3a = 3g \sin 30^\circ$   | M1    |           | Two term equation of motion   |
|              | $a = g \sin 30^\circ = 4.9 \text{ ms}^{-2}$   | A1    | 2         | AG Correct acceleration from correct working (Allow $a = g \sin 30^\circ$ )   |
| (b)(i)       | $5 = \frac{1}{2} a \times 2^2$  | M1    |           | Constant acceleration equation with $u = 0$   |
|              | $a = 2.5 \text{ ms}^{-2}$   | A1    | 2         | AG Correct answer from correct working.<br>(Use of $v = 5$ must be justified)   |
| (ii)         | $3 \times 2.5 = 3g \sin 30^\circ - F$   | M1    |           | Three term equation of motion   |
|              | $F = 3g \sin 30^\circ - 7.5$  | A1    |           | Correct equation  |
|              | $= 7.20 \text{ N}$ (to 3 sf)  | A1    | 3         | Correct $F$<br>Accept 7.2 N   |
| (iii)        | $R = 3g \cos 30^\circ$ (= 25.46)  | M1    |           | Resolving perpendicular to the slope to find $R$  |
|              | $7.2 = \mu \times 3g \cos 30^\circ$   | A1    |           | Correct $R$   |
|              | $\mu = \frac{7.2}{3g \cos 30^\circ} = 0.283$  | M1    |           | Use of $F = \mu R$  |
|              |   | A1F   | 5         | Correct expression  |
| (iv)         | Reduce $a$ , as the air resistance would reduce the magnitude of the resultant force or because the air resistance increases as the velocity increases towards its terminal value | A1F   | 5         | Correct $\mu$<br>Accept 0.282<br>(Follow through from incorrect $F$ from above, but not an incorrect $R$ )  |
|              |   | B1    |           | Reduces   |
|              |   | B1    | 2         | Explanation<br>Second B1 dependent on the first B1 mark   |
| <b>Total</b> |   |       | <b>15</b> |   |

**MM1B (cont)**

| <b>Q</b>    | <b>Solution</b>   | <b>Marks</b>         | <b>Total</b> | <b>Comments</b>   |
|-------------|---|----------------------|--------------|---|
| <b>7(a)</b> | A particle or no spin<br>No air resistance or no wind or only gravity acting  | B1<br>B1             | 2            | First assumption<br>Second assumption<br><br>If more than 2 assumptions given, subtract one mark for each incorrect additional assumption |
| <b>(b)</b>  | $0 = 25 \sin 40^\circ t - 4.9t^2$<br>$0 = t(25 \sin 40^\circ - 4.9t)$<br>$t = 0$ or $t = \frac{25 \sin 40^\circ}{4.9}$<br>Time of flight = 3.28 s | M1<br>A1<br>dM1      |              | Equation for time of flight<br>Correct equation<br>Solving for $t$  |
| <b>(c)</b>  | $s = 3.28 \times 25 \cos 40^\circ = 62.8$ m   | A1                   | 4            | AG Correct final answer from correct working<br>(Verification method M1A1M1A0)  |
| <b>(d)</b>  | $25 \text{ ms}^{-1}$ at $40^\circ$ <b>below</b> the horizontal  | M1<br>A1             | 2            | Finding range<br>Correct range  |
| <b>(e)</b>  | $v_{\min} = 25 \cos 40^\circ = 19.2 \text{ ms}^{-1}$<br><b>OR</b><br>$v_{\min} = \frac{62.807}{3.2795} = 19.2 \text{ ms}^{-1}$                    | B1<br>B1<br>M1<br>A1 | 2<br>2<br>2  | Speed<br>Direction<br>Horizontal component of velocity<br>Correct speed<br>Accept $19.1 \text{ ms}^{-1}$                                  |
|             | <b>Total</b>  |                      | <b>12</b>    |   |

## MM1B (cont)

| Q    | Solution   | Marks   | Total     | Comments   |
|------|--|---|-----------|--|
| 8(a) | $\mathbf{u} = 5\mathbf{i}$ or $\begin{bmatrix} 5 \\ 0 \end{bmatrix}$   | B1  | 1         | Correct velocity   |
| (b)  | $\mathbf{v} = 5\mathbf{i} + (-0.2\mathbf{i} + 0.25\mathbf{j})t$  | M1<br>A1  | 2         | Use of constant acceleration equation, with $\mathbf{u}$ and $\mathbf{a}$ not zero<br>Correct velocity<br>M1A0 for using $5\mathbf{j}$ or just 5   |
|      | <b>OR</b><br>$\mathbf{v} = \begin{bmatrix} 5 - 0.2t \\ 0.25t \end{bmatrix}$  |   |           |  |
| (c)  | $5 - 0.2t = 0$<br>$t = \frac{5}{0.2} = 25$ seconds   | M1<br>A1<br>A1                                  | 3         | Easterly component zero<br>Correct equation<br>Correct $t$   |
| (d)  | $\mathbf{r} = 5\mathbf{i} \times 25 + \frac{1}{2}(-0.2\mathbf{i} + 0.25\mathbf{j}) \times 25^2$<br>$= 62.5\mathbf{i} + 78.125\mathbf{j}$<br>$\theta = \tan^{-1}\left(\frac{62.5}{78.125}\right)$<br>$= 38.7^\circ$ | M1<br>A1F<br>A1<br>dM1<br>A1F<br>A1             | 6         | Use of constant acceleration equation with $t$ from part (c)<br>Correct expression based on $t$ from part (c)<br>Correct simplification CAO<br>Using tan to find the angle<br>Correct expression based on $t$ from part (c), with correct two values(either way)<br>Correct angle<br>Accept $38.6^\circ$ or $39^\circ$ |
|      | <b>OR</b><br>$\mathbf{r} = \frac{1}{2}(5\mathbf{i} + 6.25\mathbf{j}) \times 25$<br>$\theta = \tan^{-1}\left(\frac{5}{6.25}\right) = 38.7^\circ$  | (M1)<br>(A1F)<br>(A1)<br>(dM1)<br>(A1F)<br>(A1) |           |  |
|      | <b>Total</b>   |   | <b>12</b> |  |
|      | <b>TOTAL</b>   |   | <b>75</b> |  |