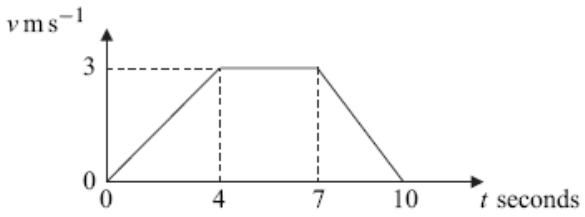
# Teacher Support Materials 2008

# GCE Mathematics Mechanics 1B

# Paper Reference: MM1B

***Question 1***

1 The diagram shows a velocity–time graph for a lift.

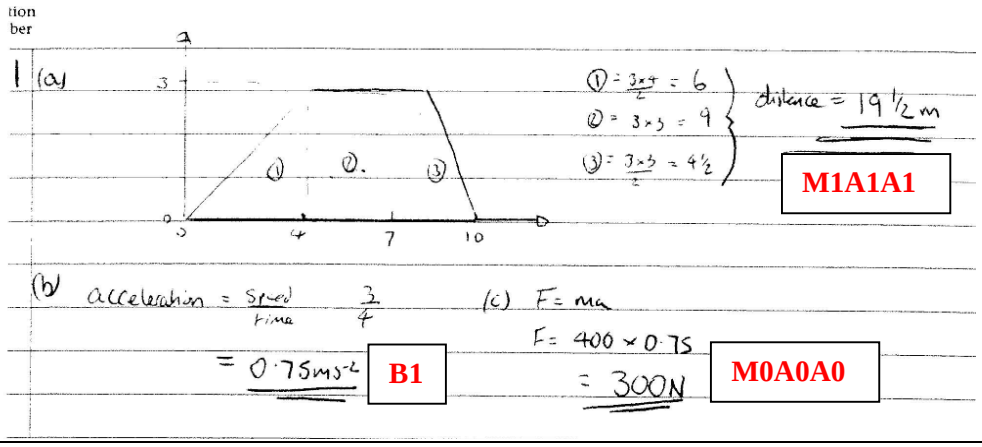



(a) Find the distance travelled by the lift. *(3 marks)*

(b) Find the acceleration of the lift during the first 4 seconds of the motion. *(1 mark)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 400 kg. Find the tension in the cable during the first 4 seconds of the motion. *(3 marks)*

***Student Response***




***Commentary***

This script shows some very clear work in part (a). The candidiate has sketched the graph, shown clearly how the area of each section has been calculated and then found the total area and hence the distance travelled correctly.

In part (b) the candidate gains full marks for their answer. Howvever it should be noted that the definition of acceleration given by the candidate is not really correct. A more appropriate definition would have contained “change in velocity” rather than “speed”. In the examiners view, it would be very harsh to penalise candidates in this case.

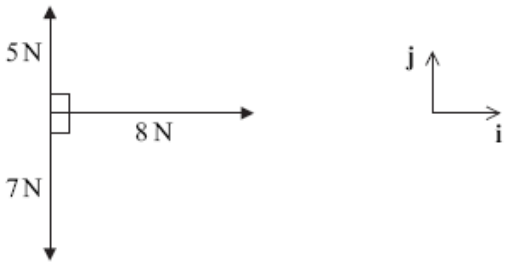
In part (c) a standard error is seen. This candidate simply calculates the product of the mass and acceleration. There is no consideration of the forces actong or a diagram to help picture the forces that are acting. Encouraging candidates to draw simple force diagrams, may help to avoid answers of this type.

***Mark scheme***

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 1(a) | $s=\frac{1}{2}(3+10)\times 3$ | M1 | | Finding distance by summing 3 areas or using formula for the area of a trapezium |
| | | A1 | | Correct equation/3 correct expressions for the areas |
| | $=19.5$ m | A1 | 3 | Correct total distance |
| (b) | $a=\frac{3}{4}=0.75$ ms$^{-2}$ | B1 | 1 | Correct acceleration as a decimal or as a fraction |
| (c) | $T-400g=400\times 0.75$ | M1 | | Three term equation of motion containing $T$, $400g$ and $400 \times 0.75$ or equivalent |
| | | A1F | | Correct equation |
| | $T=3920+300=4220$ N | A1F | 3 | Correct tension<br>Only ft from $a=\frac{4}{3}$<br>(ft 4453 N or 4450 N from $a=\frac{4}{3}$ scores M1A1A1) |
| | **Total** | | 7 | |

## *Question 2*

**2** The diagram shows three forces and the perpendicular unit vectors **i** and **j**, which all lie in the same plane.

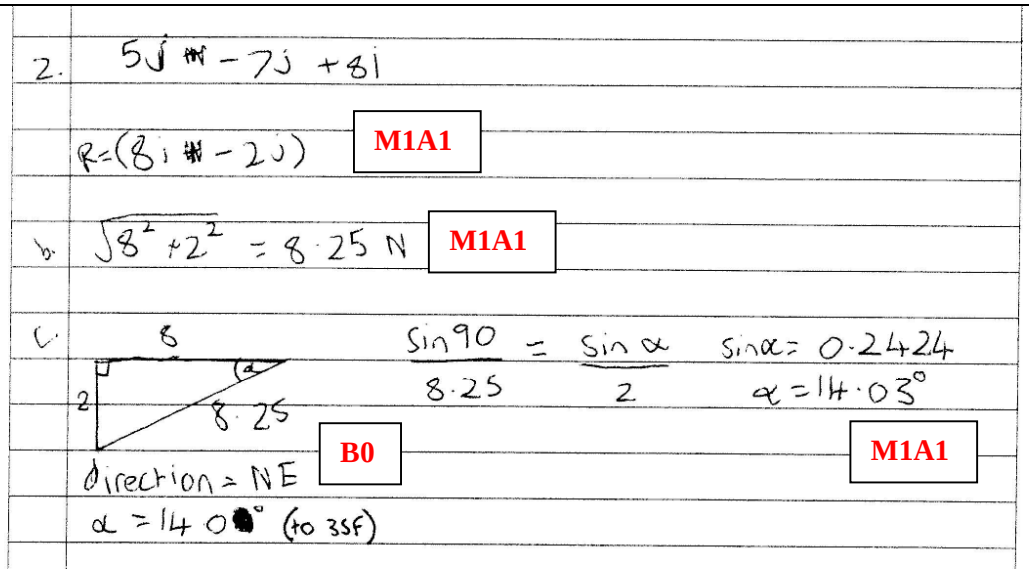



(a) Express the resultant of the three forces in terms of **i** and **j**. *(2 marks)*

(b) Find the magnitude of the resultant force. *(2 marks)*

(c) Draw a diagram to show the direction of the resultant force, and find the angle that it makes with the unit vector **i**. *(3 marks)*

## *Student response*



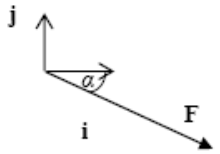
## *Commentary*

This candidate gains full marks in parts (a) and (b) of the question. The correct resultant force is calculated in part (a) and then the correct magnitude is obtained in part (b).

Part (c) shows an example of a problem that was evident on some scripts. Although the candidate has a correct expression for the resultant force, it is represented incorrectly on their diagram. the diagram shown in the working suggests that the candidate does not know how to represent vector addition geometrically. The absence of any arrows is also interested and adds further evidence to suggest that vector addition is not fully understood.

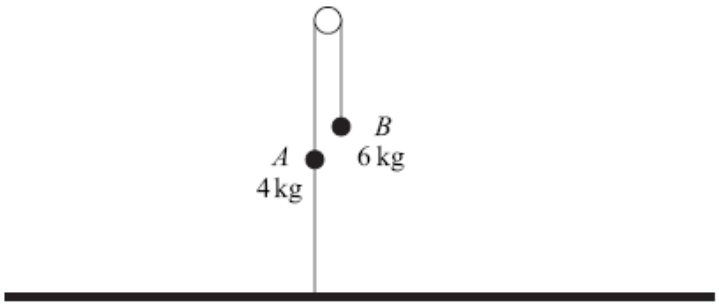
The candidate does however find the angle of 14° and gains marks doing this. It is interesting that the candidate uses the sine rule to find this angle, rather than standard right angled trigonometry. This type of approach was taken by other candidates, and while it does give the correct answer seems to be a somewhat heavy approach.

## *Mark Scheme*

| | | | | |
|---|---|---|---|---|
| **2(a)** | $\mathbf{F} = 5\mathbf{j} + 8\mathbf{i} - 7\mathbf{j} = 8\mathbf{i} - 2\mathbf{j}$ | M1 | | Adding the two forces. For incorrect answers, evidence of adding must be seen |
| | | A1 | 2 | Correct resultant |
| **(b)** | $F = \sqrt{8^2 + 2^2} = \sqrt{68} = 8.25$ N | M1 | | Finding magnitude (must see addition and not subtraction) |
| | | A1F | 2 | Correct magnitude<br>Accept $2\sqrt{17}$ , $\sqrt{68}$ or AWRT 8.25 (eg 8.246) |
| **(c)** |  | B1 | | Diagram with force in the correct quadrant and with correct direction shown by an arrow. |
| | $\tan\alpha = \frac{2}{8}$ | M1 | | Using trig to find angle: if tan, 8 in denominator; if sin or cos, 8.25 or their answer to part (b) in denominator |
| | $\alpha = 14.0°$ | A1 | 3 | Correct angle<br>Accept 14.1 or 14 or AWRT 14.0 (eg 14.04)<br>M1 and A1 not dependent on B1 |
| | **Total** | | 7 | |

## *Question 3*

3 Two particles, $A$ and $B$, have masses 4 kg and 6 kg respectively. They are connected by a light inextensible string that passes over a smooth fixed peg. A second light inextensible string is attached to $A$. The other end of this string is attached to the ground directly below $A$. The system remains at rest, as shown in the diagram.

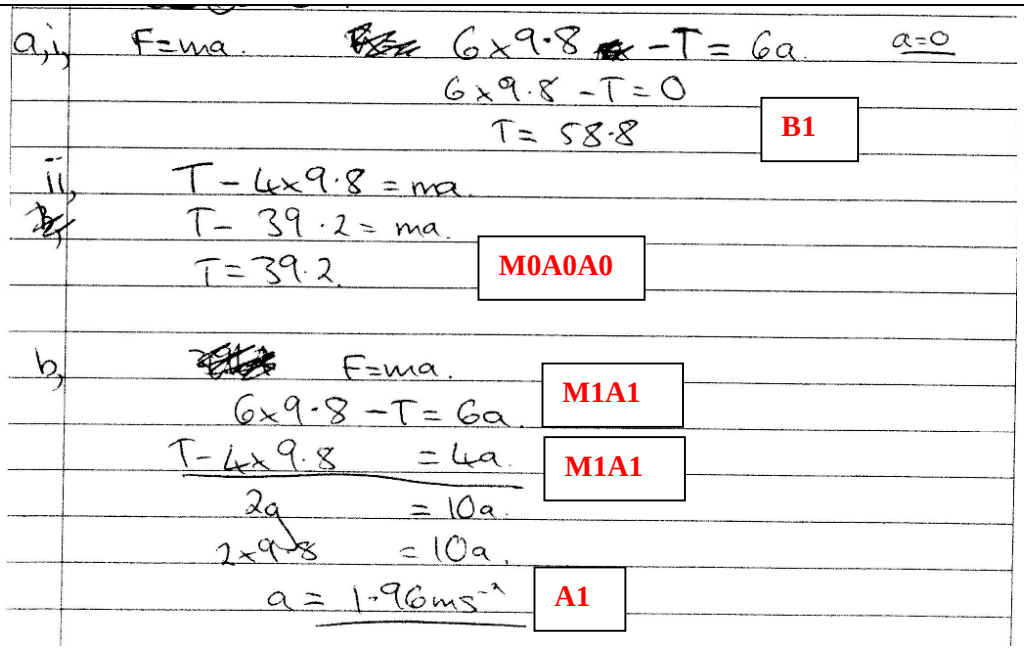



(a) (i) Write down the tension in the string connecting $A$ and $B$. *(1 mark)*

(ii) Find the tension in the string connecting $A$ to the ground. *(3 marks)*

(b) The string connecting particle $A$ to the ground is cut. Find the acceleration of $A$ after the string has been cut. *(5 marks)*

## *Student Response*



## *Commentary*

This candidate gains full marks for (a) part (i). All of the forces acting on the 6kg particle are considered and there is also a clear statement that the acceleration is zero.

The answer to (a) part (ii) only includes two force, a tension and the weight. A diagram to show the forces would have helped this candidate at this stage. Interestingly the equation contains both an *m* and an *a*, which are not explicitly assigned any values, although the calculations imply that one of them is zero. The omission of the second tension, as seen here was a fairly common error.

Part (b) was done well by this candidate who gained full marks, with a clearly set out solution. Many candidates who gained few or no marks on part (a) were able, like this candidate, to gain full marks on the more familiar situation given in part (b). It is interesting to note that this candidates seems to change between "9.8" and "*g*" in his working.

## *Mark Scheme*

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **3(a)(i)** | $T = 6\times9.8 = 58.8$ N | B1 | 1 | Use of tension being equal to the weight<br>Accept $6g$ |
| **(a)(ii)** | $58.8 = T + 4\times9.8$ | M1 | | Three term equation for equilibrium containing 58.8, $T$ and $4\times9.8$ or equivalent terms.<br>For M1, 58.8 can be replaced by candidates answer to part (a)(i) provided it is not zero. |
| | | A1 | | Correct equation |
| | $T = 58.8 - 39.2$<br>$= 19.6$ N | A1 | 3 | Correct tension<br>Accept $2g$ |
| **(b)** | $6g - T = 6a$ | M1 | | Three term equation of motion for 6 kg particle containing 58.8 or $6g$, $T$ and $6a$. |
| | | A1 | | Correct equation |
| | $T - 4g = 4a$ | M1 | | Three term equation of motion for 4 kg particle containing 39.2 or $4g$, $T$ and $4a$. |
| | | A1 | | Correct equation |
| | $2g = 10a$<br>$a = 1.96$ ms$^{-2}$ | A1 | 5 | Correct acceleration<br>Candidates who work consistently to obtain $a = -1.96$ gain full marks. |
| | **Special Case** for whole system<br>$6g - 4g = 10a$ | (M1) | | Difference in weights equal to $10a$ |
| | | (A1) | | A1: Correct equation |
| | $a = 1.96$ | (A1) | (3) | A1: Correct acceleration |
| | **Total** | | **9** | |

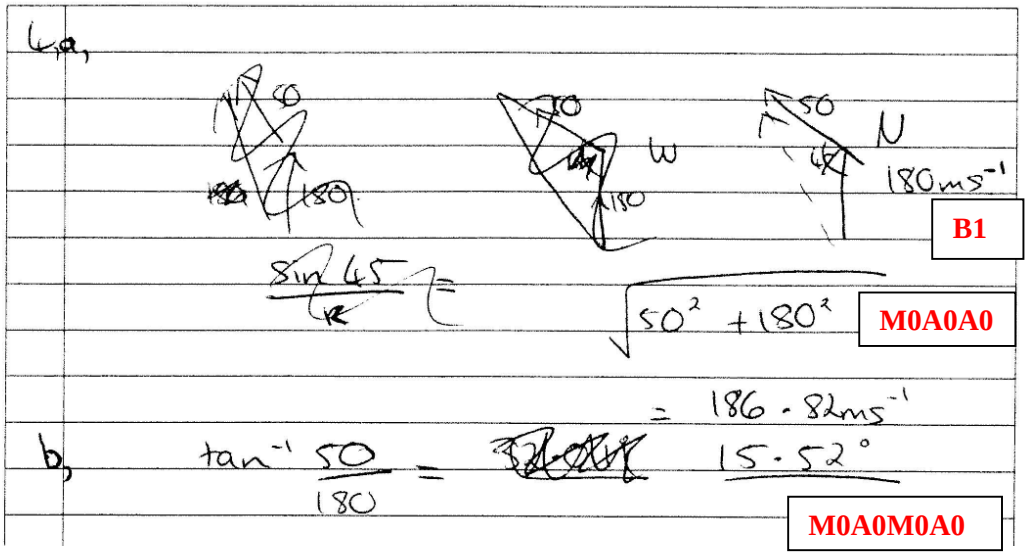
## *Question 4*

4 An aeroplane is travelling due north at $180\,\text{m s}^{-1}$ relative to the air. The air is moving north-west at $50\,\text{m s}^{-1}$.

(a) Find the magnitude of the resultant velocity of the aeroplane. *(4 marks)*

(b) Find the direction of the resultant velocity, giving your answer as a three-figure bearing to the nearest degree. *(4 marks)*

## *Student Response*

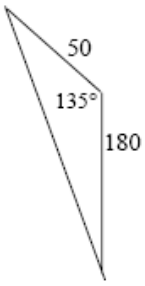



## *Commentary*

This candidate has produced a poor response to this question. The whole solution was based on the use of Pythagoras' Theorem and trigonometry in a right angled triangle. While some candidates drew right angled triangles and worked with them, this candidate wa able to produce a reasonable drawing, which was awarded one mark. In the diagram, it is easy to see the correct speeds have been used and that the directions are appropriate, but it is difficult to sure what angle is indicated. It is possible that it is considered to be 45°, but the numbers written on the script are unclear.

It is unfortunate that this candidate did not make some attempt to use the cosie rule.

## *Mark Scheme*

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **4(a)** |  | B1 | | Diagram (may be implied) The shape is sufficient, but 50 and 180 must be seen. The 135° may be replaced by 45° or be absent. |
| | $v^2 = 50^2 + 180^2 - 2\times50\times180\cos135°$ | M1 | | Use of cosine rule with 50, 180 and either 135° or 45° |
| | | A1 | | Correct equation |
| | $v = 218$ ms$^{-1}$ | A1 | 4 | Correct result for $v$ |
| | **ALTERNATIVE SOLUTION** | **OR** | | |
| | $180 + 50\cos45° = 215.36$ | (M1) | | Calculation of northerly component with 180, 50 and 45° |
| | | (A1) | | Correct component |
| | $50\sin45° = 35.36$ | (B1) | | Correct westerly component |
| | $v = \sqrt{215.36^2 + 35.36^2} = 218$ ms$^{-1}$ | (A1) | | Correct result for $v$<br>Accept AWRT 218 |
| **(b)** | $\frac{\sin\alpha}{50} = \frac{\sin135°}{218.24}$ | M1 | | Use of the sine rule with 50, 135° or 45° and AWRT 218 or candidate's answer to part (a) to at least 3SF. |
| | | A1F | | Correct equation (must have 135° not 45°). |
| | $\alpha = 9.3°$ | A1 | | Correct angle |
| | Bearing is 351° | A1 | 4 | Three figure bearing |
| | | | | Note the cosine rule could be used instead of the sine rule here. Apply mark scheme as for sine rule. |
| | **ALTERNATIVE SOLUTION** | | | |
| | $\tan\alpha = \frac{35.36}{215.36}$ | (M1) | | Use of trig to find angle |
| | | (A1) | | Correct equation |
| | $\alpha = 9.3°$ | (A1) | | Correct angle |
| | Bearing is 351° | (A1) | | Three figure bearing |
| | **Total** | | **8** | |

## *Question 5*

5 The unit vectors **i** and **j** are directed east and north respectively. A helicopter moves horizontally with a constant acceleration of $(-0.4\mathbf{i} + 0.5\mathbf{j})\,\mathrm{m\,s^{-2}}$. At time $t = 0$, the helicopter is at the origin and has velocity $20\mathbf{i}\,\mathrm{m\,s^{-1}}$.

(a) Write down an expression for the velocity of the helicopter at time $t$ seconds. *(2 marks)*

(b) Find the time when the helicopter is travelling due north. *(3 marks)*

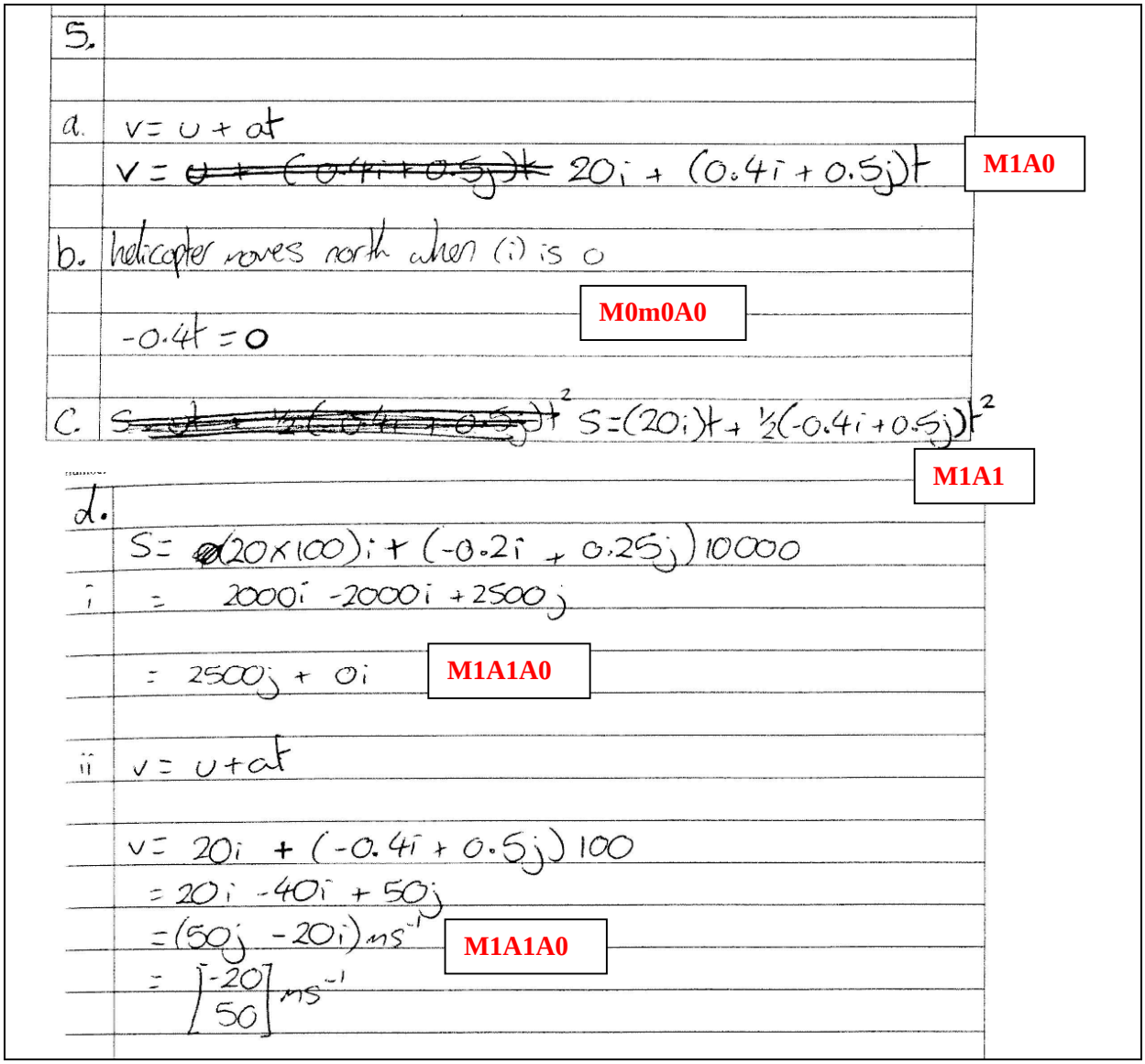
(c) Find an expression for the position vector of the helicopter at time $t$ seconds. *(2 marks)*

(d) When $t = 100$:

(i) show that the helicopter is due north of the origin; *(3 marks)*

(ii) find the speed of the helicopter. *(3 marks)*

## *Student Response*



***Commentary***

In part (a) the candidate gaisn a method mark, but loses the accuracy mark by omitting the negative sign when sunstituting the value for the acceleration. This candidate is unfortunate because a mark has been lost here simply due to a careless slip.

In part (b), the candidate correctly states that the **i** component of the velocity should be zero, but does not form a correct equation. candidates should be encouraged to write velocities and other vector quantities in the form $f(t)\mathbf{i} + g(t)\mathbf{j}$ before starting questions of this type. Interestingly the negative sign that was missing has now reappeared.

In part (c), the candidates provides a correct solution and gains full marks. It is interesting that, as in part (a), the candidate makes no attempt to simplify their answer.
In both parts (i) and (ii) of (d), the candidate gains two of the three marks available, by not completing the question. In (i) the candidates substitutes correctly and obtains the correct position vector. The candidates doesnot then complete the question by concluding that this result indicates that the helicopter is due north of the origin.

In (ii), the candidates correctly calculates the velocity of the helicopter, but does not find the speed to complete the question.

It was quite common to see scripts on which the candidates did not complete either or both of (i) and (ii) in part (d) of this question.

***Mark Scheme***

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 5 | | | | Use of column vectors is acceptable throughout this question. |
| (a) | $\mathbf{v} = 20\mathbf{i} + (-0.4\mathbf{i} + 0.5\mathbf{j})t$ | M1 | | Use of constant acceleration equation to find expression for **v** |
| | | A1 | 2 | Any correct expression. |
| (b) | $\mathbf{v} = (20 - 0.4t)\mathbf{i} + 0.5t\mathbf{j}$ | M1 | | Simplifying **v**. (May be implied.) (Missing brackets may be condoned if followed by correct working.) |
| | $20 - 0.4t = 0$ | m1 | | Putting **i** component equal to zero |
| | $t = \frac{20}{0.4} = 50$ seconds | A1 | 3 | Correct time<br>Candidates who are able to see the correct time without supporting working gain full marks.<br>Condone $\frac{20\mathbf{i}}{0.4\mathbf{i}} = 50$ |
| (c) | $\mathbf{r} = 20\mathbf{i} \times t + \frac{1}{2}(-0.4\mathbf{i} + 0.5\mathbf{j}) \times t^2$ | M1 | | Use of constant acceleration equation to find expression for **r** |
| | | A1 | 2 | Any correct expression |
| (d)(i) | $\mathbf{r} = 20\mathbf{i} \times 100 + \frac{1}{2}(-0.4\mathbf{i} + 0.5\mathbf{j}) \times 100^2$ | m1 | | Substituting $t = 100$ into their expression for **r** (dependent on M1 in part (c)) |
| | $= 2000\mathbf{i} - 2000\mathbf{i} + 2500\mathbf{j}$<br>$= 2500\mathbf{j}$ | A1 | | Correct simplified position vector ie $2500\mathbf{j}$ |
| | Therefore due north | A1 | 3 | Conclusion that helicopter is due north provided their position vector is of the form $k\mathbf{j}$, where $k>0$<br>Note if integration is used there is no need to prove that the constant is zero.<br>Note marks for (d) (i) can be awarded if part c scores zero. |
| (d)(ii) | $\mathbf{v} = (20 - 0.4 \times 100)\mathbf{i} + 0.5 \times 100\mathbf{j}$ | m1 | | Substituting $t = 100$ into their expression for **v** (dependent on M1 in part (a)) or use of other constant acceleration equation and their position vector (dependent on M1 in part (c)) |
| | $= -20\mathbf{i} + 50\mathbf{j}$ | A1 | | Correct simplified velocity |
| | $v = \sqrt{20^2 + 50^2} = 53.9$ | A1 | 3 | Correct speed (accept $10\sqrt{29}$)<br>Note marks for (d) (ii) can be awarded if part a scores zero. |
| | **Total** | | **13** | |

## *Question 6*

**6** A block, of mass 5 kg, slides down a rough plane inclined at 40° to the horizontal. When modelling the motion of the block, assume that there is no air resistance acting on it.

(a) Draw and label a diagram to show the forces acting on the block. *(1 mark)*

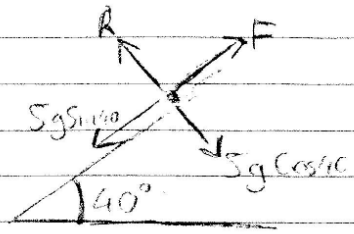
(b) Show that the magnitude of the normal reaction force acting on the block is 37.5 N, correct to three significant figures. *(2 marks)*

(c) Given that the acceleration of the block is $0.8\,\text{m}\,\text{s}^{-2}$, find the coefficient of friction between the block and the plane. *(6 marks)*

(d) In reality, air resistance does act on the block. State how this would change your value for the coefficient of friction and explain why. *(2 marks)*

***Student Response***

6 a)




B0

b) $R = 5g\cos 40$. M1A1
$= 37.5N$.

c) Applying $F=ma$.

$5g\sin 40 - F = 5 \times 0.8$.
$31.5 - F = 40$.

Sliding so $F = F_{max} = \mu R$

$\Rightarrow F = 37.5\mu$ B1

Applying $F=ma$

$5g\sin 40 - 37.5\mu = 40$. M1A0A1

$-37.5\mu = 5g\sin 40 - 40$.
$= -8.5$.
$\mu = \frac{-8.5}{-37.5}$ M1A0
$= 0.27$

d) If air resistance did act on the block, ~~the acceleration would be smaller~~ there would be no difference in the value of $\mu$ that I calculated as $\mu$ is fixed between 2 materials. B0B0

### *Commentary*

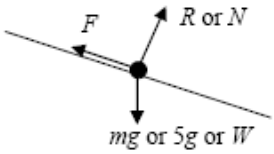
The candidate draws a force diagram which does not include the weight, but does show the two components of the weight. It seems very likely that that this diagram has helped the candidate to answer later parts of the question correctly, but does not allow marks to be gained in this part. If candidates want to include the components of a force on a diagram, they should indicate the componets in a different way, for example by using dashed lines.

Part (b) was answered well, with the candidate clearly justifying the calculation.

In part (c), the candidate make an unfortunate error, obtaining a value of 40 instead of 4. This is substituted into an otherwise correct equation. This does cause tha candidate to lose two of the accuracy marks for this part of the question.

The answer to part (d) was confused and the candidate did not grasp the fact that the value of the coefficient of friction calculated depened on the assumption that friction was the only force opposing the motion of the block. There were relatively few good answers to this part of the question.

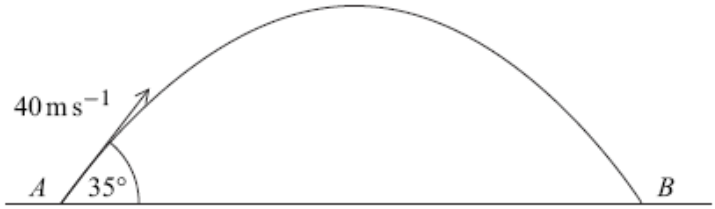
### *Mark Scheme*

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 6(a) |  | B1 | 1 | Correct force diagram with labels and arrows<br>Accept components of the weight if shown in a different notation with the weight also shown.<br>B0 if components are shown instead of the weight. |
| (b) | $(R=)5\times9.8\cos40^\circ=37.5$ N<br>**AG** | M1<br>A1 | 2 | Attempt at resolving perpendicular to the slope (eg $49\sin40^\circ$)<br>Correct value from correct working |
| (c) | $5\times0.8=5\times9.8\sin40^\circ-\mu\times5\times9.8\cos40^\circ$ | B1 | | Use of $F=\mu R$ at any stage and with any $F$ but with $R=37.5$ OE |
| | | M1 | | Three term equation of motion from resolving parallel to the slope with weight component, friction and $ma$ term. |
| | | A1 | | Correct terms seen (may be as 31.5, $37.5\mu$ (or $F$) and 4) |
| | | A1 | | Correct signs |
| | $\mu=\dfrac{5\times9.8\sin40^\circ-5\times0.8}{5\times9.8\cos40^\circ}=0.733$ | m1<br>A1 | 6 | Solving for $\mu$<br>A1: Correct value for $\mu$<br>Allow 0.732 but not $\frac{11}{15}$ unless converted to a decimal |
| (d) | There is less friction so the coefficient of friction must be less. | B1<br>B1 | 2 | Less friction<br>Smaller coefficient of friction<br>If the answer and explanation contradict each other, award no marks |
| | | | | |

## *Question 7*

7 A ball is hit by a bat so that, when it leaves the bat, its velocity is $40\,\text{m s}^{-1}$ at an angle of $35°$ above the horizontal. Assume that the ball is a particle and that its weight is the only force that acts on the ball after it has left the bat.

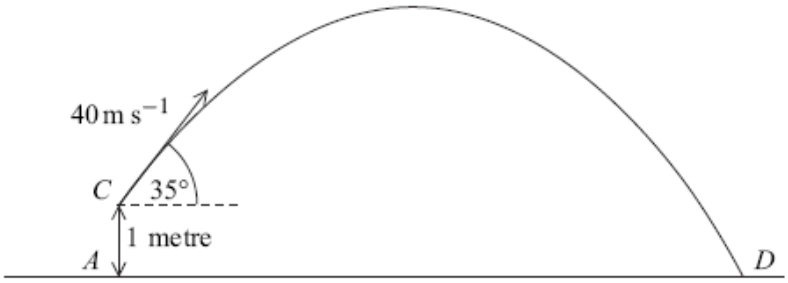
(a) A simple model assumes that the ball is hit from the point $A$ and lands for the first time at the point $B$, which is at the same level as $A$, as shown in the diagram.




(i) Show that the time that it takes for the ball to travel from $A$ to $B$ is 4.68 seconds, correct to three significant figures. *(4 marks)*

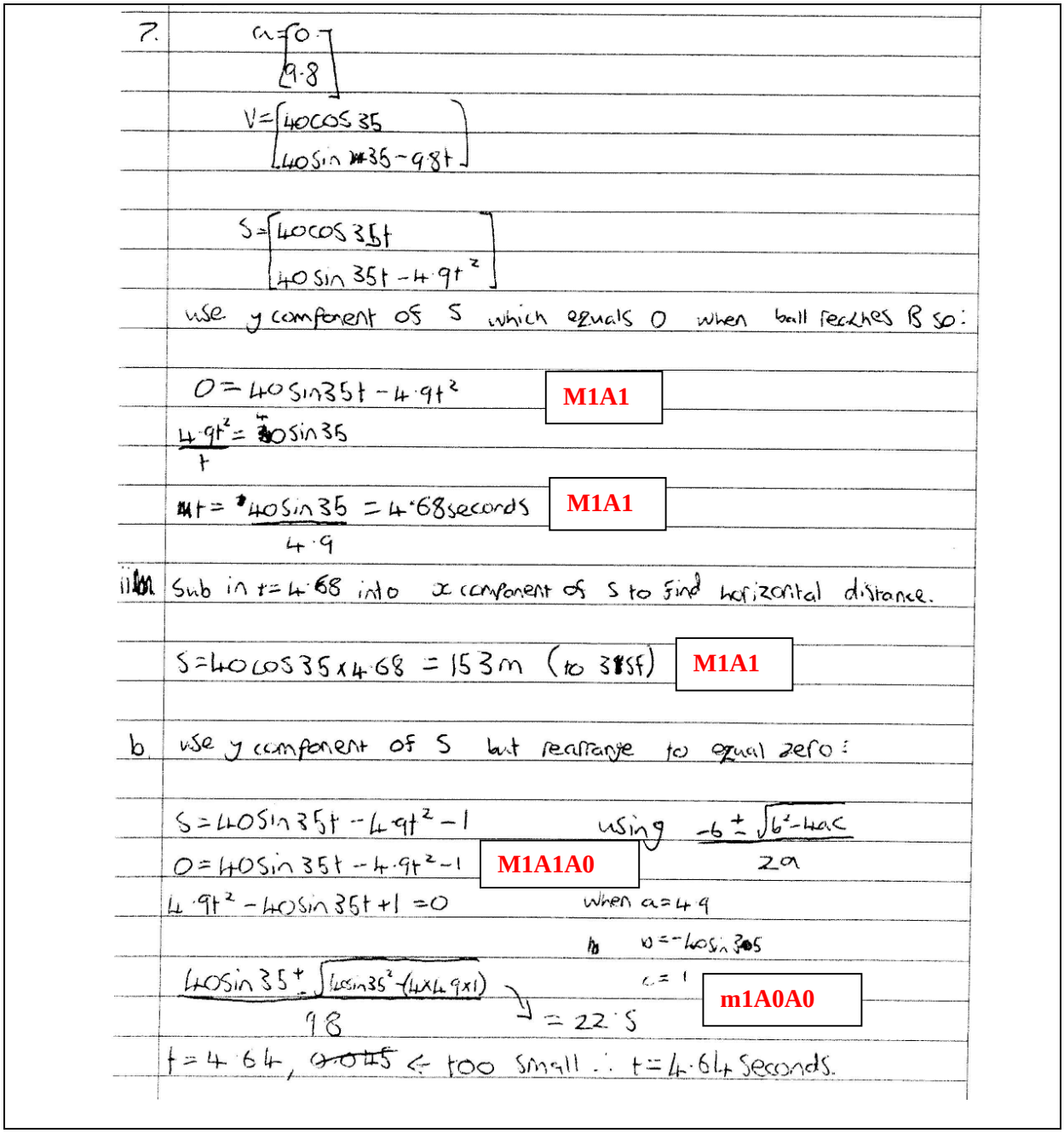
(ii) Find the horizontal distance from $A$ to $B$. *(2 marks)*

(b) A revised model assumes that the ball is hit from the point $C$, which is 1 metre above $A$. The ball lands at the point $D$, which is at the same level as $A$, as shown in the diagram.




Find the time that it takes for the ball to travel from $C$ to $D$. *(6 marks)*

## *Student Response*




## *Commentary*

This candidates produces very goos solutions to part (a). In (a) part (i) the answer is fully justified by the working shown and the examiner is left in no doubt that full marks should be awarded.

Similarly in (a) part (ii) the correct answer is clearly obtained.

In part (b), the candidate makes a common error in setting up their equation. The mistake is simply, that while a “1” is introduced into the equation, it is given the wrong sign. The candidate has not realised that a positive sign is needed as the ball is lacunched from a point one metre above ground level. The error at this stage prevents the candidate gainin all of the accuracy marks that are available in later parts of the question.

One positive feature of the work of this candidate is that both solutions to the quadratic are shown and one is selected. Some candidates did lose marks on this question because they did not show both solutions and select the appropriate value.

***Mark Scheme***

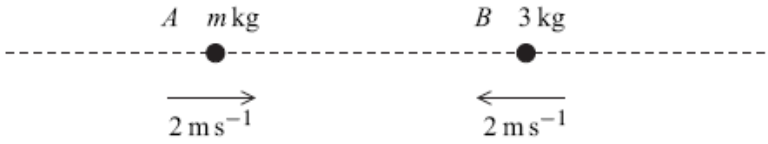
**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| 7(a)(i) | $0 = 40\sin 35° t - 4.9t^2$ | M1 | | Equation to find time of flight with 40, sin/cos35° and –4.9 or $\frac{g}{2}$ |
| | | A1 | | Correct equation |
| | $t = \frac{40\sin 35°}{4.9} = 4.68$ s **AG** | m1<br>A1 | <br>4 | Solving for $t$<br>Correct time from correct working<br>Note: candidates must have a method for the complete time of flight before any marks can be awarded.<br>Condone the use of a formula for the time of flight. |
| (a)(ii) | $AB = 40\cos 35° \times 4.682 = 153$ m | M1 | | Calculating the range using 40, cos/sin35° and 4.68 and acceleration zero. |
| | | A1 | 2 | Correct range<br>Accept AWRT 153 |
| (b) | $-1 = 40\sin 35° t - 4.9t^2$<br>$4.9t^2 - 40\sin 35° t - 1 = 0$ | M1 | | Equation to find time of flight with a ±1, 40, sin/cos35° and –4.9 or $\frac{g}{2}$ |
| | | A1<br>A1 | | Correct terms<br>Correct signs |
| | $t = \frac{40\sin 35° \pm \sqrt{(40\sin 35°)^2 - 4\times 4.9\times(-1)}}{2\times 4.9}$ | m1 | | Solving quadratic equation |
| | $t = 4.73$ or $t = -0.0432$ | A1 | | Accept AWRT 4.73 or 4.72 |
| | $t = 4.73$ | A1 | 6 | Rejection of negative solution indicated (Only 4.73 or 4.72 given award 5/6 marks) |
| | **Alternative methods** based on finding two times.<br>For example,<br>$t = 4.682 + 0.044 = 4.73$<br>$t = 2.341 + 2.384 = 4.73$ | (M1)<br>(A1)<br>(m1)<br>(A1)<br><br>(A1)<br><br>(A1) | | Addition of two times<br>Use of AWRT 4.68 or AWRT 2.34<br>Calculation of time for 'second' part<br>Correct expression for time for 'second' part<br>Correct time (Allow AWRT 0.04 or AWRT 2.38)<br>Correct total time<br>Accept 4.72 |
| | **Total** | | **12** | |

## *Question 8*

8 Two particles, $A$ and $B$, are travelling towards each other along a straight horizontal line.

Particle $A$ has velocity $2\,\text{m s}^{-1}$ and mass $m$ kg.
Particle $B$ has velocity $-2\,\text{m s}^{-1}$ and mass 3 kg.

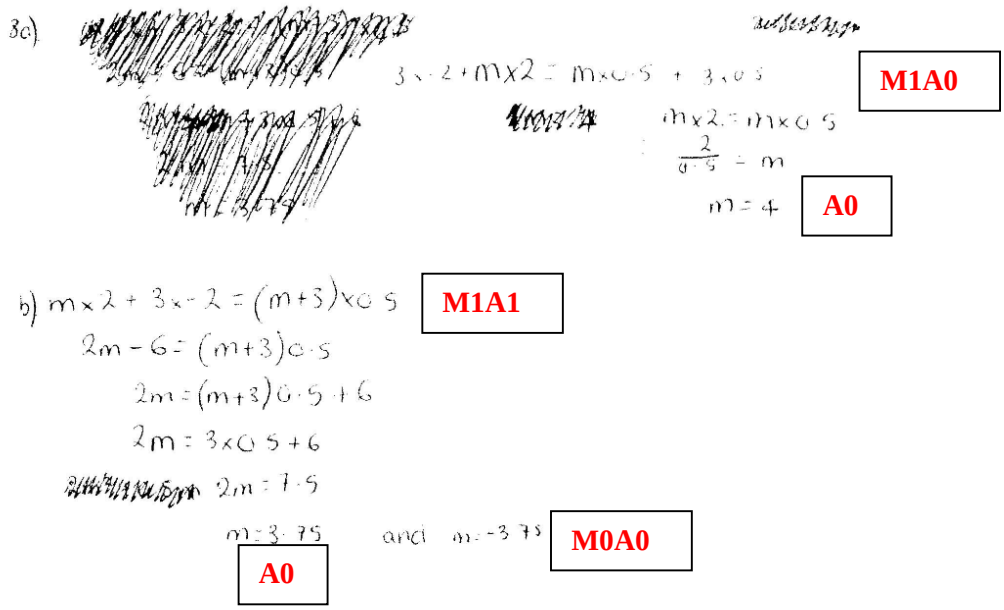



The particles collide.

(a) If the particles move in opposite directions after the collision, each with speed $0.5\,\text{m s}^{-1}$, find the value of $m$. *(3 marks)*

(b) If the particles coalesce during the collision, forming a single particle which moves with speed $0.5\,\text{m s}^{-1}$, find the two possible values of $m$. *(5 marks)*

## *Student Response*



### *Commentary*

This candidate has included an equation based on the conservation of momentum in part (a). The equation simply lacks a naegatie sign in the first term on the right hand side of the equation. It was very common to see errors with the signs of the velocities in this part of the question. This answer also shows that the candidate has some difficulties in solving the equation that has been produced.

Part (b) starts with a correct equation for the conservation of momentum for the case when the particles have a positive velocity after the collision. This approach was taken by many of the candidates. The candidate then makes an error solving his equation and ends up with an incorrectvalue for *m*.

Having obtained one value for *m*, this candidate then gives simply gives the same value of *m* a negative sign in fornt of it as the other value of *m*. The candidate does not seem to be concerned at the idea of a negative mass.

Other candidates had similar patterns of response with sign errors in part (a), followed by a correct equation for one value of *m*, sometimes with a correct solution.

### *Mark Scheme*

**MM1B (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **8(a)** | $2m-2\times3=m\times(-0.5)+3\times0.5$ | M1 | | Equation for conservation of momentum with four terms: $2m$, $2\times3$, $0.5m$ and $3\times0.5$ regardless of signs. |
| | $2.5m=7.5$ | A1 | | Correct equation with correct signs |
| | $m=3$ kg | A1 | 3 | Correct mass<br>Arguments based on the symmetry of the situation that lead to $m=3$ can be awarded full marks.<br>Note: Consistent use of $mg$ instead of $m$: deduct one mark.<br>Note: Use of all positive signs leads to $m=-3$, which might be changed to +3 by candidates (M1A0A0).<br>Note: $m=3$ can be obtained via $1.5m=4.5$, which will usually score M1A0A0 |
| **(b)** | $2m-2\times3=m\times0.5+3\times0.5$ | M1 | | Four term equation for conservation of momentum with $\pm0.5$ for both velocities (no marks for $3m\times0.5$) |
| | $1.5m=7.5$ | A1 | | Correct equation |
| | $m=5$ kg | A1 | | Correct mass for velocity used |
| | or | | | |
| | $2m-2\times3=m\times(-0.5)+3\times(-0.5)$ | M1 | | Equation for conservation of momentum with opposite sign for the 0.5 |
| | $2.5m=4.5$ | | | |
| | $m=1.8$ kg | A1 | 5 | Correct mass for the velocity used |
| | **Total** | | **8** | |
| | **TOTAL** | | **75** | |