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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Mechanics 1 (6677_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.

PEARSON 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
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a ‘force x distance’ term or ‘mass x distance’, if we allow them to cancel ‘g’ s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

‘A’ marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

‘B’ marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General 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 $\surd$ 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
- 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. 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.

6. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a 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. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- 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
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1a	Resolving horizontally: $T\cos 30° = 6\cos 50°$ $T = 4.45$ (N), 4.5 (N), or better	M1A1 A1 (3)
b	Resolving vertically: $W = 6\cos 40° + T\cos 60°$ $= 6.82$ (N), 6.8 (N), or better	M1A1 A1 (3)
		[6]

Notes for Question 1

<u>Question 1(a)</u>

First M1 for resolving horizontally with correct no. of terms and both T_{AC} and '6' terms resolved.
First A1 for a correct equation in T_{AC} only.
Second A1 for 4.5 (N), 4.45 (N) or better. (4.453363194)
N.B. The M1 is for a *<u>complete method</u>* to find the tension so where two resolution equations, neither horizontal, are used, the usual criteria for an M mark must be applied to *both* equations and the first A1 is for a correct equation in T_{AC} *only* (i.e. W eliminated correctly)

<u>Alternatives</u>:

Triangle of Forces : $\frac{T_{AC}}{\sin 40°} = \frac{6}{\sin 60°}$ (same equation as → resolution) M1A1

Or

Lami's Theorem: $\frac{T_{AC}}{\sin 140°} = \frac{6}{\sin 120°}$ (same equation as → resolution) M1A1

<u>Question 1(b)</u>

First M1 for resolving vertically with correct no. of terms and both T_{AC} (does not need to be substituted) and '6' terms resolved.
First A1 for a correct equation in T_{AC} and W.
Second A1 for 6.8 (N), 6.82 (N) or better. (6.822948256)

<u>Alternatives</u>:

Triangle of Forces : $\frac{6}{\sin 60°} = \frac{W}{\sin 80°}$ M1A1

Or Lami's Theorem: $\frac{6}{\sin 120°} = \frac{W}{\sin 100°}$ M1A1

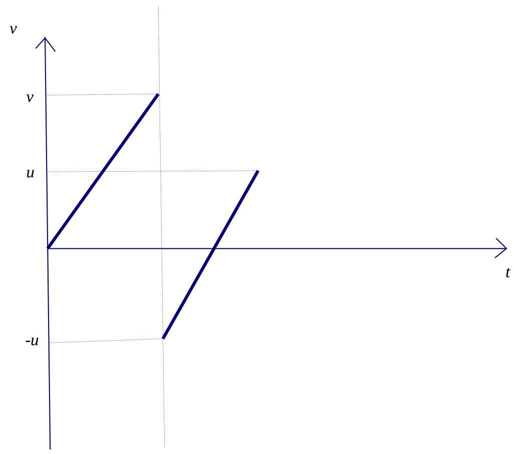
Or Resolution in another direction e.g. along one of the strings M1 (usual criteria) A1 for a correct equation.

Question Number	Scheme	Marks
2(a)	$R = mg\cos 40$	B1
	Use of $F = \mu R$	B1
	$mg\sin 40 - F = \pm ma$	M1A1
	$acc = 2.55$ (m s^{-2}) or 2.5 (m s^{-2})	A1 (5)
(b)	$v^2 = u^2 + 2as = 2 \times a \times 3$ Speed at B is 3.9 (m s^{-1}) or 3.91(m s^{-1})	M1A1 (2)
		[7]

Notes for Question 2

(Deduct only 1 mark in **whole question** for not giving an answer to either 2 sf or 3 sf, following use of g = 9.8)

Question 2(a)
First B1 for $R = mg\cos 40^{o}$
Second B1 for $F = \mu R$ seen or implied(can be on diagram)
M1 for resolving parallel to plane, correct no. of terms, mg resolved (F does not need to be substituted)
First A1 for a correct equation
Second A1 for 2.5 (ms^{-2}) or 2.55 (ms^{-2}) Must be **positive.**
S.C. If m is given a specific numerical value, can score max B1B1M1A0A0
Question 2(b)
M1 is for a complete method for finding speed (usually $v^2=u^2+2as$)
A1 for 3.9 (ms^{-1}) or 3.91(ms^{-1})

Question Number	Scheme	Marks
3a	Using $v^2 = u^2 + 2as$: $v^2 = 4g$, $v = \sqrt{4g}$ or 6.3 or 6.26 (m s^{-1})	M1,A1 (2)
b	Rebounds to 1.5 m, $0 = u^2 - 3g$, $u = \sqrt{3g}$, 5.4 or 5.42 (m s^{-1})	M1A1 (2)
c	Impulse = $0.3(6.3 + 5.4) = 3.5$ (Ns)	M1A1 (2)
d	If speed downwards is taken to be positive:  First line Second line *-u,u,*	B1 B1 B1 (3)
e.	Use of suvat to find t_1 or t_2, $\sqrt{4g} = gt_1$ $t_1 = \sqrt{\frac{4}{g}} = 0.64$ s $\sqrt{3g} = gt_2$ $t_2 = \sqrt{\frac{3}{g}} = 0.55$ s Total time = $t_1 + 2t_2 = 1.7$ s or 1.75 s	M1A1 (t_1 or t_2) **DM**1A1 (4) **[13]**

Notes for Question 3
N.B. Deduct only 1 mark in **whole question** for not giving an answer to either 2 sf or 3 sf, following use of g = 9.8 or use of g = 9.81 **Question 3(a)** M1 is for a complete method for finding speed (usually $v^2=u^2+2as$) A1 for $v = 6.3$ (ms^{-1}) or 6.26 (ms^{-1}) or $\sqrt{4g}$ (ms^{-1}) (must be positive) *Allow* $0= u^2 - 4g$ *or* $v^2 = 4g$ *but not* $0= u^2 + 4g$ *or* $v^2 = - 4g$ **Question 3(b)** M1 is for a complete method for finding speed *Allow* $0= u^2 - 3g$ *or* $v^2 = 3g$ *but not* $0= u^2 + 3g$ *or* $v^2 = - 3g$ A1 for 5.4 (ms^{-1}) or 5.42 (ms^{-1}) or $\sqrt{3g}$ (ms^{-1}) (must be positive) **Question 3(c)** M1 is for ± 0.3(their (b) $\pm$ their (a)) (unless they are definitely adding the momenta i.e. using $I = m(v + u)$ which is M0). *N.B. Extra g is M0* A1 for 3.5 (Ns) or 3.50 (Ns) (must be positive) **Question 3(d)** First B1 for a straight line from origin to their v *which must be marked on the axis.* Second B1 for a parallel straight line correctly positioned (*if continuous vertical lines are clearly included as part of the graph then B0)* Third B1 for their $-u$ and u correctly marked, *provided their second line is correctly positioned* **N.B.** A reflection of the graph in the t-axis (upwards +ve) is also acceptable **Question 3(e)** First M1 for use of *suvat* or area under their v-t graph to find either t_1 or t_2 or $2t_2$ First A1 for correct value for either t_1 or t_2 *(can be in terms of g at this stage or surds or unsimplified e.g.6.3/9.8)* Second M1 **dependent on the first M1** for their $t_1 + 2t_2$ Second A1 for 1.7 (s) or 1.75 (s).

Question Number	Scheme	Marks
4a	Resolving vertically: $T + 2T\,(=3T) = W$	M1A1
	Moments about A: $2W = 2T \times d$	M1A1
	Substitute and solve: $2W = 2\dfrac{W}{3}d$	**DM1**
	$d = 3$	A1 (6)
b	Resolving vertically: $T + 4T = W + kW \quad \left(5T = W(1+k)\right)$	M1A1 **ft**
	Moments about A: $2W + 4kW = 3 \times 4T$	M1A1 **ft**
	Substitute and solve: $2W + 4kW = \dfrac{12}{5}W(1+k)$	**DM1**
	$2 + 4k = \dfrac{12}{5} + \dfrac{12}{5}k$	
	$\dfrac{8}{5}k = \dfrac{2}{5}, \qquad k = \dfrac{1}{4}$	A1 (6)
		[12]

Notes for Question 4

N.B. In moments equations, for the M mark, all terms must be force x distance but take care in the cases when the distance is 1.

Question 4(a)

N.B. If Wg is used, mark as a misread. *If T and 2T are reversed, mark as per scheme NOT as a misread.*

First M1 for an equation in W and T and possibly d (either resolve vertically or moments about any point other than the mid-pt), with usual rules.

First A1 for a correct equation.

Second M1 for an equation in W and T and possibly d (either resolve vertically or moments about any point other than the mid-pt), with usual rules.

Second A1 for a correct equation.

Third M1, dependent on first and second M marks, for solving for d

Third A1 for $d = 3$ cso

N.B. If a single equation is used (see below) by taking moments about the mid-point of the rod, $2T = 2T(d - 2)$, this scores M2A2 (-1 each error)

Third M1, dependent on first and second M marks, for solving for d

Third A1 for $d = 3$ cso

Question 4(b)

N.B. If Wg and kWg are used, mark as a misread.

If they use any results from (a), can score max M1A1 in (b) for one equation.

If T and 4T are reversed, mark as per scheme NOT as a misread.

First M1 for an equation in W and a tension T_1 and possibly their d or their d and k (either resolve vertically or moments about any point), with usual rules.

First A1 **ft** on their d, for a correct equation.

Second M1 for an equation in W and **the same tension** T_1 and possibly their d or their d and k (either resolve vertically or moments about any point), with usual rules.

Second A1 **ft** on their d, for a correct equation.

Third M1, dependent on first and second M marks, for solving to give a numerical value of k

Third A1 for $k = 1/4$ *oe* cso

Question Number	Scheme	Marks
5a	$\mathbf{F} = m\boldsymbol{a}$: $3\mathbf{i} - 2\mathbf{j} = 0.5\boldsymbol{a}$	M1
	$\boldsymbol{a} = 6\mathbf{i} - 4\mathbf{j}$	A1
	$\lvert \boldsymbol{a} \rvert = \sqrt{6^2 + (-4)^2} = 2\sqrt{13}$ **(m s^{-2}) ****	M1A1 (4)
b	$\boldsymbol{v} = \boldsymbol{u} + \boldsymbol{a}t$: $\boldsymbol{v} = (\mathbf{i} + 3\mathbf{j}) + 2(6\mathbf{i} - 4\mathbf{j})$	M1A1 **ft**
	$= 13\mathbf{i} - 5\mathbf{j}$ m s^{-1}	A1 (3)
c	Distance = $2\lvert\mathbf{v}\rvert = 2\sqrt{4+1} = 2\sqrt{5} = 4.47$ **(m)**	M1A1
		(2)
d	When $t = 3.5$, velocity of P is $(\mathbf{i} + 3\mathbf{j}) + 3.5(6\mathbf{i} - 4\mathbf{j}) = 22\mathbf{i} - 11\mathbf{j}$	M1A1 **ft**
	Given conclusion reached correctly. E.g. $22\mathbf{i} - 11\mathbf{j} = 11(2\mathbf{i} - \mathbf{j})$	A1 **(3)**
		[12]

Notes for Question 5

<u>Question 5(a)</u>

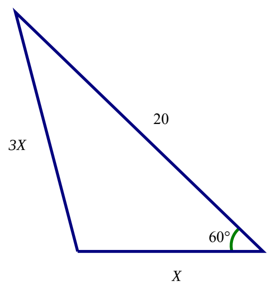
Either:
First M1 for use of **F** = m **a**
First A1 for **a** = 6**i** – 4**j**
Second M1 for $a = \sqrt{(6^2 + (-4)^2)}$ (Allow $\sqrt{(6^2 + 4^2)}$)
Second A1 for $a = 2\sqrt{13}$ (ms^{-2}) **Given answer**

Or:
First M1 for $F = \sqrt{(3^2 + (-2)^2)}$ (Allow $\sqrt{(3^2 + 2^2)}$)
First A1 $F = \sqrt{13}$
Second M1 for $\sqrt{13} = 0.5\,a$
Second A1 for $a = 2\sqrt{13}$ (ms^{-2}) **Given answer**

<u>Question 5(b)</u>
M1 for **(i + 3j) + (**2 x their **a**)
First A1 **ft** for a correct expression
Second A1 for 13**i** – 5**j** ; isw if they go on to find the speed

<u>Question 5(c)</u>
M1 for $2\sqrt{(2^2 + (-1)^2)}$ or $\sqrt{(4^2 + (-2)^2)}$
A1 for $2\sqrt{5}$ or $\sqrt{20}$ or 4.5 or 4.47 or better

<u>Question 5(d)</u>
M1 for **(i + 3j)** + (3.5 x their **a**) ,or possibly, their (b) + (1.5 x their **a**)
First A1 ft for a correct expression *of form a***i** + *b***j**
Second A1 for given conclusion reached correctly *e.g.* 22**i** -11**j**=11**(**2**i** - **j**) oe **Given answer**

Question Number	Scheme	Marks
6a		
	Resolve and use Pythagoras $(X - 20\cos 60)^2 + (20\cos 30)^2 = (3X)^2$	M1 A1
	$8X^2 + 20X - 400 = 0$	A1
	$X = \dfrac{-5 \pm \sqrt{25+800}}{4} = 5.93$ **(3 SF)**	M1A1 (5)
6a alt	Cosine rule $(3X)^2 = 20^2 + X^2 - 2.20X\cos 60$ $8X^2 + 20X - 400 = 0$	M1A1 A1
	$X = \dfrac{-5 \pm \sqrt{25+800}}{4} = 5.93$ (**3SF**)	M1A1 (5)
b	$\lvert \mathbf{P} - \mathbf{Q} \rvert^2 = 20^2 + X^2 - 2X \times 20 \times \cos 120$ $\lvert \mathbf{P} - \mathbf{Q} \rvert = 23.5$ (N) (**3SF**)	M1A1 **DM1** A1 (4)
6b alt	$\lvert \mathbf{P} - \mathbf{Q} \rvert^2 = (X + 20\cos 60)^2 + (20\cos 30)^2$ $\lvert \mathbf{P} - \mathbf{Q} \rvert = 23.5$ (N) (**3SF**)	M1A1 **DM1** A1 (4)
		[9]

Notes for Question 6

In this question a misquoted Cosine Rule is M0.
The question asks for both answers to 3 SF but only penalise under or over accuracy once in this question**.**

Question 6(a)

First M1 for a complete method to give an **equation in X only** i.e. producing two components *and* usually squaring and adding and equating to $(3X)^2$ (condone sign errors and consistent incorrect trig. in the components for this M mark **BUT the x-component must be a difference)**
First A1 for a correct unsimplified equation in X *only*
e.g, allow $(\pm(X - 20\cos 60^{o}))^2 + (\pm(20\cos 30^{o}))^2 = (3X)^2$
Second A1 for any correct fully numerical *3 term* quadratic = 0
Second M1(**independent**) for solving *a 3 term* quadratic
Third A1 for 5.93

Alternative using cosine rule:
First M1 for use of cosine rule with $\cos 60^{o}$ **(M0 if they use 120^{o})**
First A1 for a correct equation unsimplified e.g, allow $\cos 60^{o}$ and $(3X)^2$
Second A1 for any correct fully numerical *3 term* quadratic = 0
Second M1(**independent**) for solving *a 3 term* quadratic
Third A1 for 5.93

Alternative using 2 applications of the sine rule:
First M1 for using $3X / \sin 60 = X / \sin a$ **AND**

Either: $X / \sin a = 20 / \sin(120^{o} - a)$
Or: $\mathbf{3}X / \sin 60^{o} = 20 / \sin(120^{o} - a)$
(These could be in terms of b where $b = (120^{o} - a)$)

First A1 for two correct equations
Second A1 for $a = 16.778..^{o}$ (or $b = 103.221..^{o}$)
Second M1 for solving:
$X / \sin a = 20 / \sin(120^{o} - a)$ **or** $3X / \sin 60^{o} = 20 / \sin(120^{o} - a)$
with <u>their a or b</u>, to find X
Third A1 for 5.93

Question 6(b)

First M1 for use of cosine rule unsimplified with $\cos 120^{o}$ **(M0 if they use 60^{o})**
First A1 for a correct expression for $|\mathbf{P} - \mathbf{Q}|$ in terms of X (does not need to be substituted)
Second M1, **dependent on first M1**, for *substituting for their X and solving for* $|\mathbf{P} - \mathbf{Q}|$
Second A1 for 23.5
Alternative using components:
First M1 for a complete method i.e. producing two components *and* squaring and adding (no square root needed) (condone sign errors and consistent incorrect trig. in the components for this M mark **BUT the x-component must be a sum)**
First A1 for a correct expression for $|\mathbf{P} - \mathbf{Q}|$
(e.g, allow $(\pm(X + 20\cos 60^{o}))^2 + (\pm(20\cos 30^{o}))^2$
Second M1, **dependent on first M1**, for *substituting for their X and solving for* $|\mathbf{P} - \mathbf{Q}|$
Second A1 for 23.5

Question Number	Scheme	Marks
7(a)	$4mg - T = 4ma$	M1A1
	$T - 3mg = 3ma$	M1A1
	Condone the use of $4mg - 3mg = 4ma + 3ma$ in place of one of these equations.	M1A1
	Reach **given answer** $a = \frac{g}{7}$ correctly ***	A1
	Form an equation in *T*: $T = 3mg + 3\left(mg - \frac{T}{4}\right)$, $T = 3mg + 3m\frac{g}{7}$, or $T = 4mg - 4m\frac{g}{7}$	M1
	$T = \frac{24}{7}mg$ or equivalent, 33.6*m*, 34*m*	A1 (7)
(b)	$v^2 = u^2 + 2as = 2 \times \frac{g}{7} \times 0.7 = 1.96$, $v = 1.4$ ms^{-1}	M1A1 (2)
(c)	$3mg - T = 3ma$ $T - 2mg = 2ma$ $a = \frac{g}{5}$	M1A1 A1 A1 (4)
(d)	$0 = 1.96 - 2 \times \frac{g}{5} \times s$	M1
	$s = \frac{5 \times 1.96}{2g} = 0.5$ (m)	A1
	Total height = $0.7 + 0.5 = 1.2$ (m)	A1 **ft** (3)
Alt d	Using energy: $3mgs - 2mgs = \frac{1}{2}3m \times 1.4^2 + \frac{1}{2}2m \times 1.4^2$	M1
	$s = \frac{2.5 \times 1.96^2}{g} = 0.5$ (m)	A1
	Total height = $0.7 + 0.5 = 1.2$ (m)	A1 **ft** (3)
		[16]

Notes for Question 7

Question 7(a)(i) and (ii)

First M1 for resolving vertically (up or down) for $B+C$, with correct no. of terms.
First A1 for a correct equation.
Second M1 for resolving vertically (up or down) for A, with correct no. of terms.
Second A1 for a correct equation.
Third A1 for $g/7$, obtained correctly. **Given answer (1.4 A0)**

Third M1 for an equation in T only
Fourth A1 for $24mg/7$ oe or $33.6m$ or $34m$

N.B. If they omit m throughout (which gives $a = g/7$), can score max M1A0M1A0A0M1A0 for part (a) BUT CAN SCORE ALL OF THE MARKS in parts (b), (c) and (d).

Question 7(b)

M1 for an equation in v only (usually $v^2=u^2+2as$)
A1 for 1.4 (ms^{-1}) allow $\sqrt{(g/5)}$ oe.

Question 7(c)

First M1 for resolving vertically (up or down) for A or B, with correct no. of terms. (**N.B.** M0 if they use the tension from part (a))
First A1 for a correct equation for A.
Second A1 for a correct equation for B.
N.B. 'Whole system' equation: $3mg - 2mg = 5ma$ earns first 3 marks but any error loses all 3
Third A1 for g/5 oe or 1.96 or 2.0 (ms^{-2}) (*allow a negative answer)*

Question 7(d)

M1 for an equation in s only using their v from (b) and a from (c).
either $0 = 1.4^2 – 2(g/5)s$ or $1.4^2 = 0 + 2(g/5)s$
First A1 for $s = 0.5$ (m) correctly obtained
Second A1 **ft** for their $0.5 + 0.7 =1.2$ (m)

Alternative using conservation of energy

M1 for an equation in s only, with correct number of terms, using their v from (b):-
$(3mgs – 2mgs) = ½\ 3m\ (1.4)^2 + ½\ 2m\ (1.4)^2$
First A1 for $s = 0.5$ (m) correctly obtained
Second A1 **ft** for their $0.5 + 0.7 =1.2$ (m)

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