GCE

Mathematics (MEI)

Unit **4761**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2015

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

Subject-specific Marking Instructions for GCE Mathematics (MEI) Mechanics strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation ‘dep *’ is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be ‘follow through’. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)

We are usually quite flexible about the accuracy to which the final answer is expressed and we do not penalise over-specification.

When a value is given in the paper
Only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case.

When a value is not given in the paper
Accept any answer that agrees with the correct value to 2 s.f.

ft should be used so that only one mark is lost for each distinct error made in the accuracy to which working is done or an answer given. Refer cases to your Team Leader where the same type of error (e.g. errors due to premature approximation leading to error) has been made in different questions or parts of questions.

There are some mistakes that might be repeated throughout a paper. If a candidate makes such a mistake, (eg uses a calculator in wrong angle mode) then you will need to check the candidate's script for repetitions of the mistake and consult your Team Leader about what penalty should be given.

There is no penalty for using a wrong value for g. E marks will be lost except when results agree to the accuracy required in the question.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

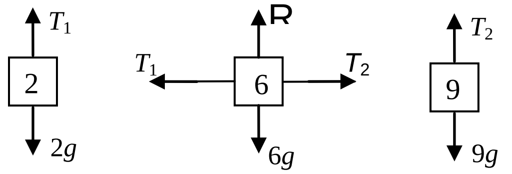
'Fresh starts' will not affect an earlier decision about a misread.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	Guidance	
1			$P = 8\sqrt{2}\sin 45° + 12\sin 30°$	**M1**	Considering equilibrium in the vertical direction	
				M1	Resolution of forces of 12 N and $8\sqrt{2}$ N in the vertical direction. Do not allow sin-cos interchange for the 30^{o} angle.	
			$P = 14$	**A1**	Dependent on both M marks	
			$Q + 8\sqrt{2}\cos 45° = 12\cos 30°$	**B1**		
			$Q = 2.39$	**B1** **[5]**		

2	**(i)**			**B1** **B1** **B1** **[3]**	Diagrams for both 2 and 9 kg blocks. The tensions must be different from each other. No extra forces. Tensions on 6 kg block. The tensions must be different from each other. No extra forces. $6g$ and R on 6 kg block. No extra forces. **Special Case** When the tensions are given as T_1, T_2, T_3, T_4 (or equivalent) award up to SC1 SC0 for the first two marks.	
2	**(ii)**		$9g - T_2 = 9a$ $T_2 - T_1 = 6a$ $T_1 - 2g = 2a$ $a = \frac{7}{17}g = 4.04$ (m s^{-2}) $T_1 = 27.7$ (N) $T_2 = 51.9$ (N)	**M1** **M1** **A1** **A1** **A1** **[5]**	First equation correct Both the remaining two equations correct. Do not give this mark if both tensions are shown as the same. The final three marks are dependent on both M marks a, T_1 and T_2 may be found in any order and FT should be allowed from the first of these found	
	(ii)		**Alternative: Whole system** $9g - 2g = 17a$ $a = \frac{7g}{17} = 4.04$ $T_1 - 2g = 2a$ and $9g - T_2 = 9a$ $T_1 = 27.7$ (N) $T_2 = 51.9$ (N)	 **M1** **A1** **M1** **A1** **A1**	 Both equations correct. Oe. The final two marks are dependent on both M marks. T_1 and T_2 may be found in either order and FT should be allowed from their value for a.	

3	**(i)**		**Either** $-2+8t=7t$ **Or** $t=10-4t$	**M1**	Forming an equation for t. Accept vector equation for this mark. May be implied by a statement that $t = 2$.	
			$\Rightarrow t=2$	**A1**		
			Substituting $t=2$ in **both** expressions	**B1**	oe, eg showing $t=2$ satisfies both equations or a vector equation.	
			They meet at (14, 2)	**B1**	Accept $\begin{pmatrix}14\\2\end{pmatrix}$	
				[4]		
3	**(ii)**		Ashok's speed is $\sqrt{8^2+1^2}=\sqrt{65}$	**B1**		
			Kumar's speed is $\sqrt{7^2+(-4)^2}=\sqrt{65}$ km h^{-1}	**B1**		
			They both walk at the same speed	**B1**	CAO from correct speeds SC1 for finding both velocities correctly but neither speed	
				[3]		

Follow through between parts of Question 4 should be allowed for the value of *a* found in part (i) into parts (ii) and (iii).						
4	**(i)**		$v^2 - u^2 = 2as$ $31^2 - 12^2 = 2 \times 215 \times a$ $a = 1.9$ so 1.9 m s^{-2}	**M1** **A1** **[2]**	Selection and use of appropriate equation(s)	
4	**(ii)**		$v = u + at$ $31 = 12 + 1.9t$ $t = 10$ so 10 s	**M1** **A1** **[2]**	Selection and use of appropriate equation(s) FT from their value of *a* from part (i).	

4	**(iii)**		$s = ut + \frac{1}{2}at^2$			
			$\frac{215}{2} = 12t + \frac{1}{2} \times 1.9 \times t^2$	**M1**	Selection and use of $s = ut + \frac{1}{2}at^2$, oe. Correct elements but condone minor arithmetic errors.	
			$\left(t = \frac{-12 \pm \sqrt{12^2 + 4 \times 0.95 \times 107.5}}{1.9} \right)$	**M1**	Use of quadratic formula (may be implied by answer), oe.	
			$t = 6.055$ (or -18.69)	**A1** **[3]**	FT their *a* only.	
			Alternative: Finding a 2-stage method			
			$v^2 - u^2 = 2as$ and $s = \frac{(u+v)}{2}t$			
			$v = \pm\sqrt{12^2 + 2 \times 1.9 \times 107.5} = (\pm)23.505...$	**M1**	Selection and use of a complete valid 2-stage method	
			$s = \frac{(u+v)}{2}t \Rightarrow t = \frac{2 \times 107.5}{(12 + 23.505...)}$ $\left(\text{or } t = \frac{2 \times 107.5}{(12 - 23.505...)} \right)$	**M1**	Using the output from the first stage to find *t*	
			$t = 6.055$ (or 18.69)	**A1**	FT their *a* only.	

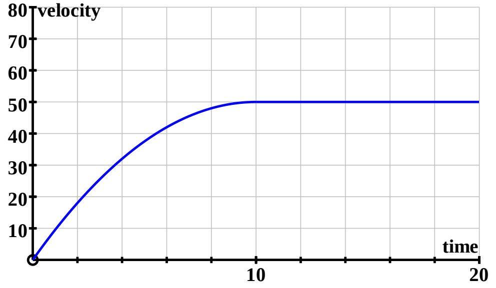
4	**(iv)**		Because it is accelerating, it travels less fast in the first half of the distance and so takes more time.	**B1** **[1]**	The answer must refer to the two parts of the distance (or "the same distance") so no credit is given to answers like "Because it is accelerating" and "Because its speed is not uniform". Most successful answers will refer to the times to cover AM and MB but this may be implicit. So B1 should be given for an answer like "It is travelling faster between M and B than it is between A and M" Notice that the fact that the acceleration is uniform is irrelevant.	

5	**(i)**		$x = 10t$ $y = 10\sqrt{3}t - 4.9t^2$	**B1** **B1** **[2]**	Allow $x = 20\cos 60^{\circ}\, t$ Allow $y = 20\sin 60^{\circ}\, t - \frac{g}{2}t^2$ or $y = 17.3\, t - \frac{9.8}{2}t^2$	
5	**(ii)**		Substitute $t = \frac{x}{10}$ in equation for y $\Rightarrow y = \sqrt{3}x - 0.049x^2$	**M1** **A1** **[2]**	Substitution of a correct expression for *t*. Notice that this is a given result	
5	**(iii)**		When $y = 0$, $x = \frac{1.732}{0.049}$ (or 0) The range is 35.3 m	**M1** **A1** **[2]**	Use of $y = 0$, or 2 × Time to maximum height	
5	**(iv)**		When $x = 20, y = 1.732 \times 20 - 0.049 \times 20^2$ Height is 15.04 m so passes below the bird whose height is 16 m	**M1** **A1** **[2]**	Use of equation of trajectory **Special Case** Allow **SC2** for substituting $y = 16$ in the trajectory, showing the equation for *x* has no real roots and concluding the height of the ball is always less than16 m. This can also be done with the equation for vertical motion.	
	(iv)		**Alternative: Using time** When $x = 20$, $t = 2$ $y = 10\sqrt{3} \times 2 - 4.9 \times 2^2$ Height is 15.04 m so passes below the bird whose height is 16 m	**M1** **A1**	Use of equation for the height	
	(iv)		**Alternative: Maximum height** The maximum height of the ball (is 15.3 m) Since15.3 < 16, it is always below the bird	**M1** **A1**	A valid method for finding the maximum height	

Follow through between parts of Question 6 should be allowed for values found in parts (ii) and (iii) providing the questions are not simplified.						
6	**(i)**		$F - R = ma$ $300 - R = (750 + 50) \times 0.25$ $R = 100$	**M1** **A1** **A1** **[3]**	Use of Newton's 2nd Law Correct elements present This is a given result	
6	**(ii)**		**Carol in** Component of weight down slope $= 800g\sin 1.5°\ (= 205.2\text{ N})$ Martin has to overcome 305.2 N $300 < 305.2$ Martin cannot manage	**M1** **A1** **A1**	Resolving down the slope. Accept use of 750 instead of 800. For this mark only condone no *g* and allow sin-cos interchange. Give M1 A1 for 800*g*sin15° seen This mark may be awarded for an argument based on Newton's 2nd law leading towards *a* = -0.006	
			Carol out Martin has to overcome $750g\sin 1.5° + 100 = 292.4\text{N}$ $300 > 292.4$ so Martin manages $300 - 292.4 = 7.6 = 750a$ The acceleration is 0.010 m s^{-2}	**B1** **M1** **A1** **[6]**	Explanation, based on correct working, that Martin can manage. This can be given retrospectively with a comment on a positive value for *a*. Use of Newton's 2nd Law Cao. Accept 0.01 or an answer that rounds to 0.01.	
6	**(iii)**		Component of Carol's force parallel to the line of the car $= 150\cos 30°\ (= 129.9)$ Resultant forward force $= 7.6 + 129.9 = 137.5$ $750a = 137.5$ The acceleration is 0.183 m s^{-2}	**M1** **A1** **M1** **A1** **[4]**	For attempt at resolution in the correct direction. For this mark only, condone sin-cos interchange. Give M1 A1 for 150cos30° seen All forces parallel to the slope present and correct. Sign errors condoned. FT their force parallel to the slope from part (ii) (correct value 7.6 N)	

6	**(iv)**		Component of weight down the slope			
			$=(750+50+80)\times 9.8\times \sin 3°$			
			$880a = 451.3 - 100$	**M1**	Newton's 2nd law with correct elements present. No sin-cos interchange. The same mass must be used in both places.	
			$a = 0.399$	**A1**		
			$v^2 - u^2 = 2as$			
			When $v = 8$, $s = 8^2 \div (2\times 0.399)$	**M1**	Selection and use of an appropriate formula (unless with $a = g$)	
			$s = 80.1$	**A1**	FT their value of a	
			$80.1 < 100$ so Yes they get the car started	**A1**	FT their value of a	
				[5]		
	(iv)		**Alternative: Finding the speed after 100 m**			
			Component of weight down the slope			
			$=(750+50+80)\times 9.8\times \sin 3°$	**M1**	Newton's 2nd law with correct elements present. No sin-cos interchange	
			$880a = 451.3 - 100$			
			$a = 0.399$	**A1**		
			$v^2 - u^2 = 2as$			
			$v^2 = (0^2) + 2\times 0.399\times 100$	**M1**	Selection and use of an appropriate formula (unless with $a = g$)	
			$v = (\sqrt{79.8}) = 8.93...$	**A1**	FT their value of a	
			(v > 8) so they get the car started	**A1**	FT their value of a	

Follow through between parts of Question 7 should be allowed for the value of *h* (when *t* = 10) found in part (iii) if it is used in part (iv) or in part (v)(*A*).

7	**(i)**		Integrate a to obtain v	**M1**	Attempt to integrate	
			$v = 10t - \frac{1}{2}t^2 \quad (+c)$	**A1**		
			$t = 10 \Rightarrow v = 100 - 50 = 50$	**M1**	Substitution of $t = 10$ to find v	
			Since $a = 0$ for $t > 10$, $v = 50$ for $t > 10$	**A1**	Sound argument required for given answer. It must in some way refer to $a = 0$.	
				[4]		
7	**(ii)**		Continuous two part v-t graph 	**B1**	The graph must cover $t = 0$ to $t = 20$	
			Curve for $0 \le t \le 10$	**B1**		
			Horizontal straight line for $10 \le t \le 20$	**B1**	B0 if no vertical scale is given	
				[3]		

7	**(iii)**		Distance fallen = $\int\left(10t - \frac{1}{2}t^2\right)\mathrm{d}t$ $d = 5t^2 - \frac{1}{6}t^3 + c \quad (c = 0)$ Height = 1000 – d Height = $1000 - 5t^2 + \frac{1}{6}t^3$ When $t = 10$, $h = 667$	**M1** **A1** **A1** **B1** **[4]**	Attempt to integrate This mark should only be given if the signs are correctly obtained. oe	
7	**(iv)**		Time at constant vel $= 667 \div 50 = 13.3$ Total time $t = 10 + 13.3 = 23.3$	**B1** **B1** **[2]**	FT for h from part (iii) FT	
7	**(v)**	***A***	Since $500 > 333$ The box will have reached terminal speed. So there is no improvement	**M1** **A1** **[2]**	For finding the height at which the crate reaches terminal velocity, eg h = 167, or equivalent relevant calculation. FT for h from part (iii) if used. Allow either one (or both) of these two statements.	
7	**(v)**	***B***	$v = 10t - t^2$ (for $t \le 5$) Terminal velocity is 25 m s^{-1} So better	**M1** **A1** **A1** **[3]**	Integration to find v	

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