OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4761**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2016

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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

1. **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.

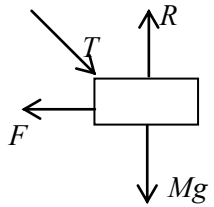
'Fresh starts' will not affect an earlier decision about a misread.

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.

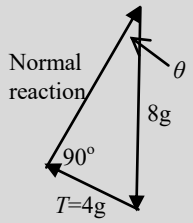
SECTION A

Qu	Part	Answer	Mark	Guidance
1.	(i)		B1 B1 B1	Forces **B0** if one force missing or an extra force present Labels Arrows **B0** if T in tension Allow T given in components provided it is clear they are not additional forces. Allow sin-cos interchange in this case. Give **B0 B0 B0** if 2 or more forces missing
			[3]	
	(ii)			Notice that the same solution applies if the direction of T was wrong in part (i), and full marks are available for part (ii) in this case.
		$T\cos\alpha - F = ma$	M1	Horizontal equation of motion with the right 3 elements
		$40\cos\alpha - F = 5\times 1.5$	A1	A0 if sin-cos interchange
		$F = 12.5$ Frictional force of 12.5 N.	A1	CAO
			[3]	

Qu	Part	Answer	Mark	Guidance
2.	(i)	$s = ut + \frac{1}{2}at^2$		The final mark scheme will include commonly used alternative methods.
		$t = 2 \Rightarrow 2u + 2a = 12$	B1	Allow one equation with $v = 0$ and $t = 4$
		$t = 6 \Rightarrow 6u + 18a = 12$	B1	
		Solving the simultaneous equations	M1	Attempt to solve non-trivial simultaneous equations in u and a
		$u = 8,\ a = -2$	A1	CAO
			[4]	
	(ii)	At B, $v^2 - u^2 = 2as$		Follow through for their values of u and a.
		$\Rightarrow\ 0^2 - 8^2 = 2 \times -2 \times s$	M1	Allow the use of $s = ut + \frac{1}{2}at^2$ with $t = 4$.
		$s = 16$	A1	
		AB is 4 m.	A1	CAO
			[3]	

Qu	Part	Answer	Mark	Guidance
3.	(i)	$T = 8a$	B1	
		$4g - T = 4a$	B1	Allow if a is in the upwards direction but the two equations must be consistent in this.
			[2]	
	(ii)	Adding the two equations $\Rightarrow$ $4g = 12a$	M1	Or equivalent method. No FT from part (i).
		$a = \frac{g}{3}$ (-3.27 m s^{-2})	A1	CAO but allow 3.26 .
			[2]	
	(iii)	Equilibrium equations $T - 4g = 0$ $T - 8g\sin\theta = 0$ $4g - 8g\sin\theta = 0$	 M1 M1 A1	 Vertical equation Award if $8g\sin\theta$ seen. Do not allow sin-cos interchange Correct equation with $T = 4g$ substituted
				Note Award **M1 M1 A1** for going straight to $4g = 8g\sin\theta$ oe Allow **M1 M1 A0** for $4 = 8\sin\theta$ with no previous work
		$\Rightarrow$ $\theta = 30°$	A1	CAO
			[4]	

4761 June 2016 Addition to Mark scheme Alternative method for 3(iii)

3.	(iiii)	**Alternative**		
		$T - 4g = 0$	**M1**	
		Triangle of forces for the 8 kg block  	**M1**	Dependent on the other M mark There must be an attempt to use the triangle for this mark to be awarded. The triangle must be labelled with $4g$, $8g$ and θ . The right angle must be drawn close to 90^{o}.
		$\sin\theta = \frac{4g}{8g}$	**A1**	Dependent on both M marks.
		$\theta = 30°$	**A1**	CAO

Qu	Part	Answer	Mark	Guidance
4.	(i)	$\mathbf{u} = \begin{pmatrix} 2 \\ 6 \end{pmatrix}$	B1	
		$\mathbf{a} = \begin{pmatrix} 0 \\ -8 \end{pmatrix}$	B1	
			[2]	
	(ii)	$\mathbf{v} = \mathbf{u} + \mathbf{a}t$		
		$t = 2 \Rightarrow \mathbf{v} = \begin{pmatrix} 2 \\ 6 \end{pmatrix} + \begin{pmatrix} 0 \\ -8 \end{pmatrix} \times 2$	M1	Or equivalent. FT for their **u** and **a**
		$= \begin{pmatrix} 2 \\ -10 \end{pmatrix}$	A1	Continue the FT for this mark
		Speed $= \sqrt{2^2 + (-10)^2} = 10.2\,\text{m s}^{-1}$ (to 3 sf)	B1	FT from their **v**
			[3]	
	(iii)	$x = ut \Rightarrow x = 2t \Rightarrow t = \frac{x}{2}$	M1	This mark may also be obtained for substituting x for $2t$ in the expression for y.
		$y = 6t - 4t^2$	B1	
		$y = 6 \times \frac{x}{2} - 4 \times \left(\frac{x}{2}\right)^2 = 3x - x^2$	A1	
			[3]	

Qu	Part	Answer	Mark	Guidance
4.	**(iii)**	**Alternative**		
		$x = 2t$		
		Substitute for x in given answer	**M1**	
		$y = 3x - x^2 \Rightarrow y = 6t - 4t^2$	**A1**	
		This is the given expression for y	**B1**	

Qu	Part	Answer	Mark	Guidance
5.		At maximum height	**M1**	For considering maximum height
		$v^2 - u^2 = 2as \;\Rightarrow\; 0^2 - 8^2 = 2\times(-9.8)\times h$	**M1**	Use of suitable *suvat* equation(s) eg finding and using t for maximum height (0.816 s). Allow for use of calculus.
		$h = 3.265...$	**A1**	CAO but allow 3.26 as well as 3.27
		($3.265... < 4$) so the stone misses the pigeon	**A1**	Dependent on previous mark
		Alternative		
		Substitute $y = 4$ in $y = 8t - 4.9t^2$	**M1**	
		Attempt to solve $4.9t^2 - 8t + 4 = 0$	**M1**	
		Discriminant (= 64 - 4 × 4.9 × 4 = - 14.4) < 0	**A1**	
		No value of t so the stone does not reach height 4 m	**A1**	
		Time to house is $\frac{22.5}{15} = 1.5$ s	**B1**	
		Height at house $= 8\times1.5 - \frac{1}{2}\times9.8\times1.5^2 = 0.975$ m	**B1**	Allow answers from essentially correct working that round to 0.96, 0.97 or 0.98, eg 0.96375 from g = 9.81
		0.8 < 0.975 < 2.0 so it hits the window.	**B1**	A 2-sided inequality must be given, either in figures or in words. Condone 0.8 < 0.975 < 1.2 Dependent on previous mark
			[7]	

SECTION B

Qu	Part	Answer	Mark	Guidance
6.	(i)	$d = 5 \times 8^2 = 320$, so 320 m	B1	
		This value is too great. It is not between 150 and 200 m.	B1	Accept "inconsistent". Dependent on previous mark.
		$s = ut + \frac{1}{2}at^2$ with $s = d$, $(u = 0)$, $a = 10$ and $t = T$	M1	
		Giving $d = \frac{1}{2} \times 10 \times T^2 = 5T^2$	A1	
			[4]	
	(ii)	Depth = Area under the graph	M1	oe
		$= \frac{1}{2} \times 5 \times 50 + 3 \times 50$	A1	
		= 275 m	A1	
		Outside the 150 to 200 m interval so inconsistent	B1	A numerical comparison is required for this mark but may refer to values for it stated in part (i). Dependent on previous mark.
				Special Case Allow up to M1 A0 A1 B1 for a response in which the time at which *v* becomes constant is near but not equal to 5 (eg 4 or 4.5).
			[4]	
	(iii)	The same: initial constant acceleration (of 10 m s^{-2})	B1	Do not allow statements about the initial speed or the time taken
		Different: two part motion with constant speed at end	B1	
			[2]	

Qu	Part	Answer	Mark	Guidance
6.	(iv)	For $0 \leq t \leq 5$, the distance travelled is $\int_0^5 (10t - t^2)\mathrm{d}t$	M1	Or equivalent using indefinite integration
		$= \left[5t^2 - \frac{t^3}{3}\right]_0^5$	A1	Limits not required for this mark
		$5 \times 5^2 - \frac{5^3}{3}$ $(= 83\frac{1}{3})$	A1	A $\Rightarrow$ M
		For $5 < t \leq 8$, the distance travelled is 25 × 3 (= 75)	B1	Seen or implied
		$d = 83\frac{1}{3} + 75 = 158\frac{1}{3}$	A1	CAO
		This is within the given interval.	B1	Dependent on previous mark
			[6]	
	(v)	Similar: constant speed for $5 < t \leq 8$	B1	
		Different: acceleration is not constant for $0 \leq t \leq 5$.	B1	
			[2]	

Qu	Part	Answer	Mark	Guidance
7.	(i)	$\cos\alpha = 0.8,\ \cos\beta = 0.6$	B1	Or equivalent statements
			[1]	
	(ii)	Horizontal forces → $8000\cos\beta - 6000\cos\alpha$	M1	Do not allow sin-cos interchange
		4800 - 4800 = 0 So the horizontal component of acceleration is 0	A1	Must state acceleration is zero
		Vertical forces ↑ $T\sin\alpha + 8000\sin\beta - 7500$	M1	Do not allow if the weight is missing Allow $T\cos\beta + 8000\cos\alpha - 7500$
		$\sin\alpha\ (=\cos\beta) = 0.6$ and $\sin\beta\ (=\cos\alpha) = 0.8$	B1	o.e. CAO May be seen or implied in the working
		6400 + 3600 -7500 = 2500	A1	CAO
		Mass of bomb $\frac{7500}{9.8}$ $(= 765.3)$ kg	M1	
		$a = \frac{2500}{765.3} = 3.27$ The acceleration is 3.27 m s^{-1} upwards	A1	CAO Allow 3.26
			[7]	

Qu	Part	Answer	Mark	Guidance
7.	(iii)	No horizontal acceleration $\Rightarrow$ Resultant = 0		
		Horizontal forces $\rightarrow$ $8000\cos\beta - T\cos\alpha = 0$	**M1**	Horizontal must be indicated
		$T = \dfrac{8000\cos\beta}{\cos\alpha}$	**A1**	
		$\cos\alpha = \dfrac{16}{\sqrt{d^2+16^2}}$, $\cos\beta = \dfrac{9}{\sqrt{d^2+9^2}}$	**M1**	
		$T = 8000 \times \dfrac{\dfrac{9}{\sqrt{d^2+81}}}{\dfrac{16}{\sqrt{d^2+256}}} = \dfrac{4500\sqrt{d^2+256}}{\sqrt{d^2+81}}$	**A1**	
			[4]	

Qu	Part	Answer	Mark	Guidance
	(iv)	When $d = 6.75$, $T = 4500 \times \dfrac{\sqrt{6.75^2 + 256}}{\sqrt{6.75^2 + 81}}$ $(= 6946.2\ ...)$	**B1**	May be implied by subsequent working Note In this situation $\alpha = 22.9^o$, $\beta = 36.9^o$
		Vertical forces ↑ $6946.2\sin\alpha + 8000\sin\beta - 7500$	**M1**	Their α and β . No sin-cos interchange . Note The forces are 2700 N and 4800N
		= 0	**A1**	Condone any resultant force that rounds to 0 to the nearest integer.
		So the (vertical) acceleration is zero.	**A1**	CAO
			[4]	
		Alternative		
		Vertical forces ↑ $T\sin\alpha + 8000\sin\beta - 7500$		
		$4500 \times \dfrac{\sqrt{6.75^2 + 256}}{\sqrt{6.75^2 + 81}} \times \dfrac{6.75}{\sqrt{6.75^2 + 256}} + 8000 \times \dfrac{6.75}{\sqrt{6.75^2 + 81}} - 7500$	**M1** **B1**	
		$12500 \times \dfrac{6.75}{11.25} - 7500 = 0$	**A1**	
		So the (vertical) acceleration is zero.	**A1**	CAO
7.	**(v)**	When at P there would be no vertical components of the tensions to counteract the weight.	**B1**	
		The acceleration would be *g* vertically downwards .	**B1**	The acceleration must be stated to be *g*
			[2]	

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