OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4761:** Mechanics 1

Mark Scheme for June 2013

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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.

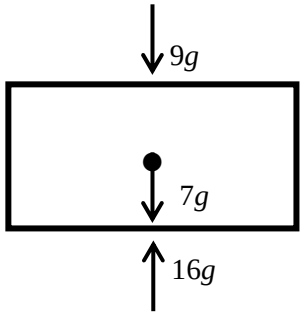
Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

'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				 B1 B1 B1 **[3]**	One mark for each force with correct magnitude and direction Deduct 1 mark only for *g* missing 16g ↑ 7g ↓ 9g ↓ If all three forces are correct but there is at least one extra force, deduct 1 mark and so give 2 marks. Otherwise ignore extra forces. Note For 16*g* ↑ 16*g* ↓ Award B1 B0 B0
2	(i)		Initial speed is 25 m s^{-1}	B1 **[1]**	

Question			Answer	Marks	Guidance
2	(ii)		Vertical motion: $y = 20t - 4.9t^2$	M1	Forming an equation or expression for vertical motion
			When $y = 0$,	M1	Finding t when the height is 0
			$T = (0 \text{ or }) \dfrac{20}{4.9} = 4.08$ s	A1	
			$R = 15 \times 4.08... = 61.22$	F1	Allow $15\times$ their T Note If horizontal and vertical components of the initial velocity are interchanged treat it as a misread; if no other errors are present this gives 3 marks.
				[4]	
			Alternative Using time to maximum height		
			Vertical motion: $v = 20 - 9.8t$	M1	Forming an equation or expression for vertical motion
			Flight time = 2 × Time to top	M1	Using flight time is twice time to maximum height or equivalent for range.
			$T = 2 \times \dfrac{20}{9.8} = 4.08$ s	A1	
			$R = 15 \times 4.08... = 61.22$	F1	Allow $15\times$ their T
			Alternative Using formulae		
			Finding angle of projection $\alpha = \arctan\left(\dfrac{20}{15}\right) = 53.1°$	M1	Only award this mark if there is a clear intention to use this method
			$R = \dfrac{2u^2 \sin\alpha\cos\alpha}{g} = \dfrac{2 \times 25^2 \times \sin 53.1° \times \cos 53.1°}{9.8}$	M1	Allow the alternative form $R = \dfrac{u^2 \sin 2\alpha}{g}$ with substitution
			$R = 61.2$	A1	
			$T = \dfrac{2u\sin\alpha}{g} = 4.08$	A1	

Question			Answer	Marks	Guidance
2	(iii)	(*A*)	Flight time $= \frac{15}{4.9}$ Range $= 20 \times \frac{15}{4.9} = 61.22$	B1 **[1]**	Allow FT from part (ii) for a correct argument that they should be the same
2	(iii)	(*B*)	No eg angle of projection 45^o	M1 A1 **[2]**	Attempt at disproof or counter-example. There must be some reference to the angle. Complete argument

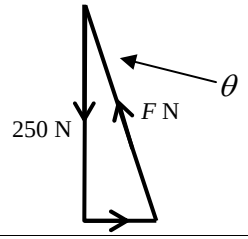
Question			Answer	Marks	Guidance
3	(i)		**p** $\sqrt{(-1)^2+(-1)^2+5^2}=\sqrt{27}$ **q** $\sqrt{(-1)^2+(-4)^2+2^2}=\sqrt{21}$ **r** $\sqrt{2^2+5^2+0^2}=\sqrt{29}$ Greatest magnitude: **r**	M1 A1 **[2]**	Use of Pythagoras Note Magnitudes are 5.196, 4.583 and 5.385 respectively
3	(ii)		Weight $=\begin{pmatrix}0\\0\\-4\end{pmatrix}$ $\mathbf{p}+\mathbf{q}+\mathbf{r}+\mathbf{weight}=\begin{pmatrix}0\\0\\3\end{pmatrix}$ $0.4\mathbf{a}=\begin{pmatrix}0\\0\\3\end{pmatrix}$ Magnitude of acceleration is 7.5 m s^{-2} Direction is vertically upwards	B1 B1 B1 B1 **[4]**	Condone $g=9.8$ giving weight is $\begin{pmatrix}0\\0\\-3.92\end{pmatrix}$ N. Accept 4↓. $g=9.8$ gives $\begin{pmatrix}0\\0\\3.08\end{pmatrix}$ Relevant attempt at Newton's 2nd Law. The total force must be expressed as a vector in some form. For this mark allow the weight to be missing, in the wrong component or to have the wrong sign. Condone *mg* in place of *m* for this mark only. CAO apart from using $g=9.8 \Rightarrow a=7.7$

Question	Answer	Marks	Guidance
4	Equate **i** and **j** components of **v**	M1	The candidate recognises that the **i** and **j** components must be equal.
	$16-t^2=31-8t$	A1	An equation is formed.
	$t^2-8t+15=0$		
	$(t-3)(t-5)=0$		
	$t=3$ or 5	A1	May be implied by later working.
	When $t=3$, $\mathbf{v}=7\mathbf{i}+7\mathbf{j}$	B1	
	Speed when $t=3$ is $7\sqrt{2}=9.9$ m s^{-1}	B1	
	The values of the **i** and **j** components must both be positive for the bearing to be 045^o .	B1	This mark is dependent on obtaining A1 for the result $t=3$ or 5 . It is awarded if the speed for the case when $t=5$ is not included (since $t=5 \Rightarrow \mathbf{v}=-9\mathbf{i}-9\mathbf{j}$ and the bearing is 225^o).
			Note Candidates who obtain **r** and equate the east and north components should be awarded SC1 for the whole question.
		[6]	

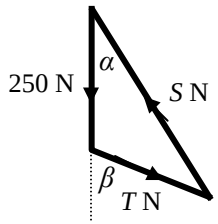
Question			Answer	Marks	Guidance
4			**Alternative Trial and error**		
			The i and j components of v must be equal	M1	The candidate recognises that the **i** and **j** components must be equal.
			The **i** and **j** components of **v** must both be positive for the bearing to be 045^o.	B1	This can be demonstrated during the question either by a suitable convincing diagram including 45^o, or by a suitable convincing argument
			At least one value of t is substituted	A1	Trial and error is used
			$t = 3$	A1	$t = 3$ is found by trial and error
			When $t = 3$, $\mathbf{v} = 7\mathbf{i} + 7\mathbf{j}$	B1	
			Speed when $t = 3$ is $7\sqrt{2} = 9.9$ m s^{-1}	B1	
					Note Candidates who obtain **r** and equate the east and north components should be awarded SC1 for the whole question.
				[6]	

Question			Answer	Marks	Guidance
5	(i)		If the acceleration is to the right		
			Overall $30 - F = (4+6) \times 2$	M1	Newton's 2nd Law in one direction. No extra forces allowed and signs must be correct.
			$F = 10$	A1	
			If the acceleration is to the left	M1	For considering second direction. No extra forces allowed and signs must be correct.
			$F = 50$	A1	
				[4]	
5	(ii)		6 kg block $30 - T = 6 \times 2$	M1	Newton's 2nd law with correct elements on either block
			$\Rightarrow T = 18$	A1	CAO No follow through from part (i)
			In the other case $T = 42$	A1	CAO No follow through from part (i)
				[3]	

Question			Answer	Marks	Guidance
6	(i)		$v = 0 \Rightarrow 3(t-2)(t-4) = 0$	M1	Setting $v = 0$ (may be implied)
			$T_1 = 2,\ T_2 = 4$	A1	Accept t = 2 and t = 4
				[2]	
6	(ii)		$x = \int v\mathrm{d}t$	M1	Use of integration
			$x = 24t - 9t^2 + t^3 + c:\ c = 0$	A1	Condone omission of c
			$t = 2 \Rightarrow x = 48 - 36 + 8 = 20$	E1	CAO
			$t = 4 \Rightarrow x = 96 - 144 + 64 = 16$	A1	CAO
				[4]	

Question			Answer	Marks	Guidance
7	(i)		 **Or equivalent**	B1 B1 B1 **[3]**	Shape of triangle; ignore position of θ if marked in diagram 2 marks -1 per error but penalise no arrows only once and penalise no labels only once. Condone *T* written for *F*. In the case of a force diagram showing F, 25 and 250 allow maximum of 2 marks with -1 per error but penalise no arrows only once and penalise no labels only once
7	(ii)		$\tan\alpha = \frac{25}{250}$ 25 N $\Rightarrow \alpha = 5.7°$ $F = \sqrt{25^2 + 250^2}$ $F = 251.2$ Distance $= 30\tan\alpha = 30\times 0.1 = 3$ m	M1 A1 M1 A1 B1 **[5]**	M1 for recognising and using α in the triangle Use of Pythagoras At least 3 significant figures required CAO
			Alternative $F\cos\theta = 250$ $F\sin\theta = 25$ $\tan\theta = \frac{25}{250}$ $\Rightarrow \theta = 5.7°$ $F\cos 5.7° = 250$ $F = 251.2$ Distance $= 30\tan\alpha = 30\times 0.1 = 3$ m	 M1 A1 M1 A1 B1	 At least 3 significant figures required CAO

Question			Answer	Marks	Guidance
7	(iii)		Vertical equilibrium	M1	M1 for attempt at resolution in an equation involving both *S* and *T*; condone sin-cos errors for the M mark only
			$\uparrow \ S\cos\alpha \ = T\cos\beta + 250 \ \downarrow$	A1	
			Horizontal equilibrium $S\sin\alpha = T\sin\beta$	A1	
				[3]	
7	(iv)		$S\sin 8.5° = T\sin 35° \Rightarrow S = 3.8805T$	M1	Using one equation to make *S* or *T* the subject in terms of the other
			$(3.8805T)\cos 8.5° = T\cos 35° + 250$	M1	Substituting in the other equation
			$T = 82.8$	A1	CAO
			$S = 321.4$	A1	CAO
				[4]	
			Alternative		**Use of linear simultaneous equations**
			$S\sin 8.5° - T\sin 35° = 0$ $S\cos 8.5° - T\cos 35° = 250$		
			$S\sin 8.5°\cos 35° - T\sin 35°\cos 35° = 0$ $S\cos 8.5°\sin 35° - T\cos 35°\sin 35° = 250\sin 35°$		
			$S(-\sin 8.5°\cos 35° + \cos 8.5°\sin 35°) = 250\sin 35°$	M1	Valid method that has eliminated terms in either *S* or *T* (execution need not be perfect)
			$S = 321.4$	A1	CAO First answer
			Substituting in either equation	M1	Substituting to find the second answer
			$\Rightarrow T = 82.8$	A1	CAO Second answer

Question			Answer	Marks	Guidance
7	(iv)		Alternative Triangle of forces		
				M1	Either Drawing and using a triangle of forces Or Quoting and using Lami's Theorem
			$\frac{S}{\sin 145°} = \frac{T}{\sin 8.5°} = \frac{250}{\sin 26.5°}$	M1	Correct form of these equations
			$S = 321.4$	A1	CAO
			$T = 82.8$	A1	CAO

Question			Answer	Marks	Guidance
7	(v)		Abi's weight is $40g = 392$ N	M1	Consideration of Abi's weight
			When $\alpha = 60°$, $S\cos 60° > 250 \Rightarrow S > 500$	M1	Consideration of vertical forces on the object. Condone no mention of Bob's rope
			The tension in rope A would be greater than Abi's weight and so she would be lifted off the ground	A1	The argument must be of high quality and must include consideration of the tension in Bob's rope
				[3]	
			Alternative		
			If Abi is on the ground, the maximum possible tension in rope A is Abi's weight of 392 N	M1	Consideration of Abi's weight
			So the maximum upward force on the object is $392 \times \cos 60° = 192$ N		
			This is less than the weight of the object, and the tension in Bob's rope is pulling the box down.	M1	Consideration of vertical forces on the object. Condone no mention of Bob's rope Or the box accelerated downwards
			So Abi would be lifted off the ground	A1	The argument must be of high quality and must include consideration of the tension in Bob's rope

Question			Answer	Marks	Guidance
8	(i)		$v = u + at$	M1	Use of a suitable constant acceleration formula
			$5 = 0 + a \times 10 \Rightarrow a = 0.5$	A1	Notice The value of a is not required by the question so may be implied by subsequent working
			$F = ma \Rightarrow 120 - R = 40 \times 0.5$	M1	Use of Newton's 2nd Law with correct elements
			$R = 100\,\text{N}$	E1	
				[4]	
8	(ii)	(*A*)	$F = ma \Rightarrow -100 = 40a$	M1	Equation to find a using Newton's 2nd Law
			$\Rightarrow a = -2.5$	A1	
			When $t = 1.6$ $v = 5 + (-2.5) \times 1.6 = 1\ \text{ms}^{-1}$	A1	CAO
				[3]	
8	(ii)	(*B*)	When $t = 6$, it is stationary. $v = 0\ \text{ms}^{-1}$	B1	
				[1]	

Question			Answer	Marks	Guidance
8	(iii)		Motion parallel to the slope:	B1	Component of the weight down the slope, ie $40g\sin 15°$ (= 101.457…)
			$200 - 40g\sin 15° = 40a$	M1	Equation of motion with the correct elements present. No extra forces.
			$a = 2.463...$		This result is not asked for in the question
			$v^2 - u^2 = 2as \Rightarrow 8^2 = 2 \times 2.46... \times s$	M1	Use of a suitable constant acceleration formula, or combination of formulae. Dependent on previous M1.
			$\Rightarrow s = 12.989...$ rounding to 13.0 m	E1	Note If the rounding is not shown for *s* the acceleration must satisfy $2.452... < a < 2.471...$
				[4]	
8	(iv)		Let *a* be acceleration up the slope		
			$-40 \times 9.8 \times \sin 15° = 40a$	M1	Use of Newton's 2nd Law parallel to the slope
			$a = -2.536...$, ie 2.536 m s^{-2} down the slope	A1	Condone sign error
			$s = ut + \frac{1}{2}at^2$		
			$-12.989... = 8t + \frac{1}{2} \times (-2.536...)t^2$	M1	Dependent on previous M1. Use of a suitable constant acceleration formula (or combination of formulae) in a relevant manner.
			$1.268...t^2 - 8t - 12.989... = 0$	A1	Signs must be correct
			$t = \dfrac{8 \pm \sqrt{64 - 4 \times 1.268... \times (-12.989...)}}{2 \times 1.268...}$	M1	Attempt to solve a relevant three-term quadratic equation
			$t = -1.339...$ or $7.647...$, so 7.65 seconds	A1	
				[6]	

Question			Answer	Marks	Guidance
8	(iv)		**Alternative 2-stage motion**		
			Let a be acceleration up the slope		
			$-40\times 9.8\times \sin 15° = 40a$	M1	Use of Newton's 2nd Law parallel to the slope
			$a = -2.536...$, ie 2.536 m s^{-2} down the slope	A1	Condone sign error
			Motion to highest point		
			$v = u + at \quad \Rightarrow \quad 0 = 8 - 2.536...t$	M1	Dependent on previous M1. Use of a suitable constant acceleration formula, for either t or s, in a relevant manner.
			$t = 3.154...$	A1	For either t or s
			$s = ut + \frac{1}{2}at^2 \Rightarrow s = 8\times 3.154... - \frac{1}{2}\times 2.536...\times 3.154...^2$		
			$s = 12.616...$		
			Distance to bottom = 12.989.. + 12. 616... = 25.605...		
			$s = ut + \frac{1}{2}at^2 \Rightarrow 25.605... = \frac{1}{2}\times 2.536...\times t^2$	M1	Use of a suitable constant acceleration formula
			$t = 4.493...$		
			Total time = 3.154... + 4.493... = 7.647 ... s	A1	

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