GCE

Mathematics (MEI)

Unit **4761**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2014

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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.

These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation in scoris	**Meaning**
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓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.

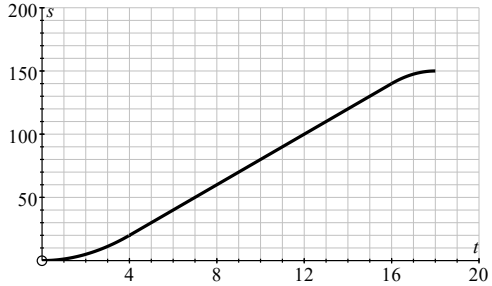
Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

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

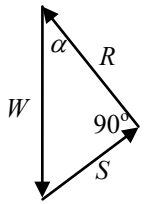
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

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	(i)		When $t = 4$, $s = \frac{1}{2} \times 4 \times 10$		Finding the area of the triangle or equivalent.	
			$s = 20$	B1		
			When $t = 18$, $s = \frac{1}{2} \times (18 + 12) \times 10$	M1	A complete method of finding the area of the trapezium or equivalent.	
			$s = 150$	A1	CAO	
				[3]		
1	(ii)					
			Graph joining (0,0), (4,20) and (18, 150)	B1	Allow FT for their (4,20) and (18, 150) Condone extension to (20, 150) with a horizontal line.	
			The graph goes through (16, 140)	B1		
					Allow SC1 for the first two marks if there is a consistent displacement from a correct scale, eg plotting (18,150) at (19, 150)	
			Curves at both ends	B1	The sections from $t = 0$ to $t = 4$ and from $t = 16$ to $t = 18$ are both curves	
				[3]		

Question			Answer	Marks	Guidance
2	(i)		$\mathbf{p} + \mathbf{q} = 28\mathbf{i} - 3.5\mathbf{j}$	B1	
			$28\mathbf{i} - 3.5\mathbf{j} = k(8\mathbf{i} - \mathbf{j})$ $k = 3.5$ (So they are parallel)	M1 A1	Or equivalent. k may be implied by going straight to 3.5
			Alternative $\mathbf{p} + \mathbf{q} = 28\mathbf{i} - 3.5\mathbf{j}$	B1	
			$\mathbf{p} + \mathbf{q}$: $\tan\theta = \frac{-3.5}{28} \Rightarrow \theta = -7.13°$ $8\mathbf{i} - \mathbf{j}$: $\tan\theta = \frac{-1}{8} \Rightarrow \theta = -7.13°$	M1	Comparing the ratio of the components in each of the two vectors is sufficient, using any consistent sign convention. The angle does not need to be worked out, nor does tan have to be seen.
			So they are parallel	A1	Both ratios the same and correct
				[3]	
2	(ii)		$3\mathbf{p} + 10\mathbf{q} = (36+160)\mathbf{i} + (-15 + 15)\mathbf{j}$ $= 196\mathbf{i}$ Zero **j** component so horizontal	B1 B1	Or equivalent explanation. May be shown on a diagram
				[2]	
2	(iii)		The horizontal component must be zero So $12k + 3\times 16 = 0 \Rightarrow k = -4$ $\mathbf{w}$ = -24.5**j** $mg = 24.5 \Rightarrow m = 2.5$ The mass is 2.5 kg	B1 B1 B1	Substituting k = -4 and showing **i** component is zero is acceptable Award for 24.5 seen Award for 2.5 seen. FT from their weight.
				[3]	

Question			Answer	Marks	Guidance	
3	(i)			B1 B1 B1 **[3]**	Closed triangle with cycling arrows. Accept any consistent orientation. All forces labelled. Correct angles. The 90° may be implied. α may be shown between S and the horizontal (ie outside the triangle). SC1 Award for a force diagram with no extra forces and all labels and directions correct.	
3	(ii)		$R = W\cos\alpha$ $S = W\sin\alpha$	B1 B1 **[2]**	Allow FT for sin-cos interchange following the wrong angle in the triangle being marked α in part (i) for both marks. SC1 if both S and R are given negative signs	
3	(iii)		 Sketch graph of R against α Correct sketch graph of S against α $45° < \alpha \ (\leq 90°)$	 B1 B1 B1 **[3]**	The answers in part (iii) must - either be fully correct - or they must all be consistent with those in part (ii) where the marks in part (ii) are FT from part (i). No credit should be given to forms other than $W\cos\alpha$ and $W\sin\alpha$. The curves must have the correct end points and lie within the correct range; no credit should be given for straight lines. Graphs must be correctly labelled. Unlabelled graphs get B0 B0. Condone no explicit vertical scale. Do not accept straight lines. Must be consistent with graph of R Condone $45° \leq \alpha$	

Question			Answer	Marks	Guidance	
4	(i)		Vertical component of initial velocity $= 20\sin 30°$ $(=10)$	B1		
			Vertical motion $s = s_0 + ut + \frac{1}{2}at^2$	M1	Substitution required. The sign of g must be correct. Condone no s_0	
			When it hits the sea $0 = 75 + 10t - 5t^2$	A1		
			$75 + 10 \times 5 - 5 \times 5^2 = 0$ As required		Or equivalent, eg solving the quadratic equation.	
			This is satisfied when $t = 5$	E1		
			Alternative			
			Vertical component of initial velocity $= 20\sin 30°$ $(=10)$	B1		
			Vertical motion $v = u + at$	M1	Complete method for finding $t = 5$ required.	
			At the top $0 = 10 - 10t \Rightarrow t = 1$			
			It takes another 1 second to reach the level of the cliff top			
			At that point its speed is 10 m s^{-1} downwards			
			When it hits the sea $-75 = -10t - 5t^2$		Or equivalent finding the time (4 seconds) from the top (height 80 m) to hitting the sea	
			$t^2 + 2t - 15 = 0 \Rightarrow t = 3$	A1		
			Total time = 1 + 1 + 3 = 5 seconds	E1		
			Horizontal motion $x = 20 \times \cos 30° \times t$	M1		
			$t = 5 \Rightarrow 86.6$			
			It is 3.4 m from the ship so within 5 m	E1	Condone 3.5 m	
				[6]		
4	(ii)		It is longer in the air so it goes further	B1	Justification for travelling further is required for this mark.	
				[1]		

Question			Answer	Marks	Guidance	
5	(i)		$v = 0$ when it arrives $150\ 000(t - \frac{1}{4}t^2) = 0$ $\Rightarrow\ t = 4$ (on arrival)	 B1 **[1]**	 Award this mark for substituting $t = 4$ to obtain $v = 0$ Condone omission of $t = 0$	
5	(ii)		Distance travelled $s = \int v\mathrm{d}t$ $s = 150\ 000\left[\frac{1}{2}t^2 - \frac{1}{12}t^3\right]\ (+c)$ When $t = 4,\ s = 400\ 000$ The journey is 400 000 km	M1 A1 M1 A1 **[4]**	Do not accept multiplication by t. Substituting their $t = 4$. This mark is dependent on the previous M mark. If 400 000 seen award the previous mark	
5	(iii)		For maximum speed $a = \frac{\mathrm{d}v}{\mathrm{d}t} = 0$ $\frac{\mathrm{d}v}{\mathrm{d}t} = 150\ 000(1 - \frac{1}{2}t)$ $\Rightarrow t = 2$ $v = 150\ 000(2 - \frac{1}{4} \times 2^2) = 150\ 000$ Maximum speed is 150 000 $\mathrm{km\,h^{-1}}$	 B1 B1 **[2]**	 $t = 2$ seen Accept a trial and error method CAO	

Question			Answer	Marks	Guidance	
6	(i)		Speed = $\sqrt{(-5)^2+0^2+(-10)^2}$ $= 11.2\ \text{m s}^{-1}$ (11.18)	M1 A1	For use of Pythagoras. Accept $\sqrt{5^2+10^2}$. Accept $\sqrt{125}$ or $5\sqrt{5}$	
			$\tan\theta = \frac{5}{10}$ $\theta = 26.6°$	M1 A1 **[4]**	Complete method for correct angle; may use $\sin\theta = \frac{5}{11.2}$, $\cos\theta = \frac{10}{11.2}$. Allow 153.4^o, 206.6^o	
6	(ii)		$\begin{pmatrix}0\\0\\-980\end{pmatrix}$ her weight $\begin{pmatrix}0\\0\\880\end{pmatrix}$ resistance to her vertical motion $\begin{pmatrix}50\\-20\\0\end{pmatrix}$ force from the power unit	B1 B1 B1 **[3]**	The descriptions should be linked to the forces, either by the layout of the answer or by suitable text. If not, assume that the forces they refer to are in the order given here (which is the same as the question). Accept "Air resistance", "Arms stretched out" and similar statements. Condone mention of a parachute.	
6	(iii)		Resultant force = $\begin{pmatrix}50\\-20\\-100\end{pmatrix}$ Acceleration = $\begin{pmatrix}0.5\\-0.2\\-1\end{pmatrix}$ Magnitude = $\sqrt{0.5^2+(-0.2)^2+1^2} = 1.1357...$ So 1.14 to 3 s.f.	B1 B1 B1 **[3]**	May be implied Newton's 2nd Law Answer given. Allow FT from sign errors. Accept $\lvert\mathbf{F}\rvert \div 100$	

Question			Answer	Marks	Guidance	
6	(iv)		$\mathbf{v} = \mathbf{u} + \mathbf{a}t$	M1	FT their **a** for the first 5 marks of this part. Vectors must be seen or implied. Accept valid integration.	
			$\mathbf{v} = \begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix} + \begin{pmatrix} 0.5 \\ -0.2 \\ -1 \end{pmatrix} t$	A1		
			$\mathbf{r} = \mathbf{r_0} + \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$	M1	Vectors must be seen or implied. Accept valid integration. Condone no $\mathbf{r_0}$ for this M mark	
			$\mathbf{r} = \begin{pmatrix} -75 \\ 90 \\ 750 \end{pmatrix} + \begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix} t + \frac{1}{2}\begin{pmatrix} 0.5 \\ -0.2 \\ -1 \end{pmatrix} t^2$	A1		
			When $t = 30$	M1	Vectors must be seen or implied.	
			$\mathbf{r} = \begin{pmatrix} -75 - 150 + 225 \\ 90 + 0 - 90 \\ 750 - 300 - 450 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$, as required	E1	CAO	
					SC1 to replace the first 4 marks of this section if the acceleration is taken to be **g** but the answer is otherwise correct.	
				[6]		
6	(v)		When $t = 30$, $\mathbf{v} = \begin{pmatrix} 10 \\ -6 \\ -40 \end{pmatrix}$	M1	There must be an attempt to work out at least the vertical component of the velocity at $t = 30$. This mark is not dependent on a correct answer.	
			The vertical component of the velocity is too fast for a safe landing	A1	Accept an argument based on speed derived from a vector.	
				[2]		

Question			Answer	Marks	Guidance	
7	(i)		Whole train: mass = 150 tonnes Total Resistance = 3000 N	B1	Both totals required.	
			$12000 - 3000 = 150000a$	M1	Correct elements must be present	
			$a = 0.06$ The acceleration is 0.06 $m\,s^{-2}$	A1	CAO. Errors with units (eg not converting tonnes to kilograms) are penalised here but condoned where possible for the remainder of the question.	
				[3]		
7	(ii)		Truck B: $T - 500 = 30000a$	M1	Correct elements must be present	
			$T - 500 = 30000 \times 0.06$	A1	Allow FT for a from part (i) if units are used consistently, for all the marks in this part	
			$T = 2300$	A1		
			Between A and B, tension of 2300 N	**[3]**		
			Alternative			
			Rest of train: 12 000 – 2500 – T = 120 000a	M1	Correct elements must be present	
			T = 12 000 –2500-120 000 × 0.06	A1		
			T = 2300	A1		
7	(iii)		Treating the train as a whole - 2000 – 5000 – 500 = 150 000a	M1		
			$a = -0.05$	A1	Allow FT for the remaining A marks in part (iii) from an error in a	
			$v^2 - u^2 = 2as$	M1		
			$0^2 - 10^2 = 2 \times (-0.05) \times s$			
			$s = 1000$ Stopping distance is 1000 m	A1		
			B: $T - 500 = 30000a$	M1	Correct elements must be present. Alternative for rest of train: -T – 5000 –2000 = 120 000 × -0.05	
			$T = -1000$	A1	The sign of 1000 must be consistent with the direction of T.	
			Between A and B, thrust of 1000 N	A1	Dependent on previous M and A marks. Accept “compression”.	
				[7]		

Question			Answer	Marks	Guidance	
7	(iv)		Equilibrium parallel to the slope $150000 \times 9.8 \times \sin\alpha + 3000 = 12000$ $\alpha = 0.35°$ **[3]**	M1 A1 A1	Correct elements must be present and there must be an attempt to resolve the weight. Condone omission of *g* for this mark. CAO	
7	(v)		B: $T_2 - 500 - 30000 \times 9.8 \times \sin 0.35...° = 0$ $T_2 = 2300$ Between A and B, tension of 2300 N, as in part (ii) **[2]**	M1 A1	Correct elements must be present. Condone omission of g for this mark. Do not accept 1800 N for the component of the weight without justification. Alternative for rest of train: $12\,000 = T + 2500 + 120\,000 \times 9.8 \times \sin 0.35^o$ This mark can only be awarded if the angle found in (iv) is correct.	

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