OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4761:** Mechanics 1

Mark Scheme for June 2012

Oxford Cambridge and RSA Examinations

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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.

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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. 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 entire 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.

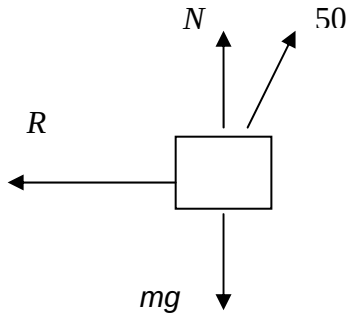
i. If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is 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	*(A)*		False This is a speed-time graph not one for displacement-time	M1 A1	**Notice** that the runner may have returned to his starting place or may not; the graph does not contain the information to tell you which is the case. **Accept** statements only if they are true and relevant, e.g.: There is no information about direction of travel There is no evidence to suggest he has turned round Distance is given by the area under the graph but this is not the same as displacement Speed is not a vector and so the area under the graph says nothing about the direction travelled It just (or only) shows speed-time **Do not accept** statements that are, or may be, untrue: eg The particle moves only in the positive direction **Do not accept** statements that are true but irrelevant: eg The distance travelled is the area under the graph **Condone** This is a speed time graph not one for distance-time
1	*(B)*		True	B1	Ignore subsequent working
1	*(C)*		True	B1	Ignore subsequent working
1	*(D)*		False The area under the graph is 420 not 400 **[6]**	M1 A1	Accept area up to time 55 s is 400 m The calculation in the false example must be correct

Question			Answer	Marks	Guidance
2	(i)		$v = \int (6t - 12)\,\mathrm{d}t$	M1	Attempt to integrate
			$v = 3t^2 - 12t + c$	A1	Condone no c if implied by subsequent working (eg adding 9 to the expression)
			$c = 9$	A1	
			$t = 3 \Rightarrow v = 3 \times 3^2 - 12 \times 3 + 9 = 0$	E1	Or by showing that $(t - 3)$ is a factor of $3t^2 - 12t + 9$
				[4]	
2	(ii)		$s = \int (3t^2 - 12t + 9)\,\mathrm{d}t$	M1	Attempt to integrate Ft from part (i)
			$s = t^3 - 6t^2 + 9t - 2$	A1	A correct value of c is required. Ft from part (i).
			When $t = 2$, $s = 0$. (It is at the origin.)	B1	Cao
				[3]	
3	(i)		**P** + **Q** + **R** = 0**i** + 0**j**	B1	Accept answer zero (ie condone it not being in vector form)
				[1]	
3	(ii)	*(A)*	The particle is in equilibrium	B1	If "equilibrium" is seen give B1 and ignore whatever else is written. Allow, instead, "acceleration is zero", "the particle has constant velocity" and other equivalent statements. Do not allow "The forces are balanced", "The particle is stationary" as complete answers
		(B)	The hiker returns to her starting point	B1	Do not allow "The hiker's displacement is zero"
				[2]	

Question			Answer	Marks	Guidance
4	(i)		At C: $s = ut + \frac{1}{2}at^2$ $500 = 5 \times 20 + 0.5 \times a \times 20^2$ $a = 2$ (ms^{-2})	 M1 A1 **[2]**	 M1 for a method which if correctly applied would give a. Cao **Special case** If 800 is used for s instead of 500, giving $a = 3.5$, treat this as a misread. Annotate it as SC SC and give M1 A0 in this part
4	(ii)		At B: $v^2 - u^2 = 2as$ $v^2 - 5^2 = 2 \times 2 \times 300$ $v = 35$ Speed is 35 m s^{-1} At B: $v = u + at$ $35 = 5 + 2 \times t$ $t = 15$ Time is 15 s	M1 A1 A1 **[3]**	M1 for a method which if correctly applied would give either v or t Apply FT from incorrect a from part (i) for the M mark only Cao. No FT from part (i) except for SC1 for 46.2 following $a = 3.5$ after the use of $s = 800$. Cao. No FT from part (i) except for SC1 for 11.7 following $a = 3.5$ after the use of $s = 800$.

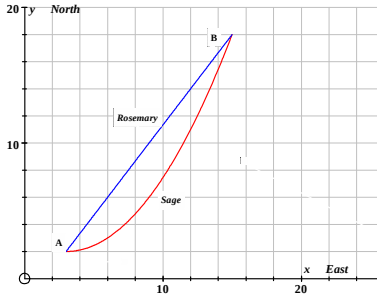
Question			Answer	Marks	Guidance
5	(i)			B2 [2]	Subtract one mark for each error, omission or addition down to a minimum of zero. Each force must have a label and an arrow. Accept T for 50 N. Units not required. If a candidate gives the tension in components: Accept if the components are a replacement for the tension Treat as an error if the components duplicate the tension However, accept dotted lines for the components as not being duplication
5	(ii)		Horizontal equilibrium : $R = 50\sin 30° = 25$	M1 A1 [2]	May be implied. Allow sin-cos interchange for this mark only Award both marks for a correct answer after a mistake in part (i) (eg omission of R)
5	(iii)		Vertical equilibrium $N + 50\cos 30° = 10g$ $N = 54.7$ to 3 s.f.	M1 A1 [2]	Relationship must be seen and involve all 3 elements. No credit given in the case of sin-cos interchange Cao
5	(iv)		Resultant $= \sqrt{25^2 + 54.7^2}$ Resultant is 60.1 N	M1 A1 [2]	Use of Pythagoras. Components must be correct but allow ft from both (ii) and (iii) for this mark only Cao

Question			Answer	Marks	Guidance
6	(i)		**Either**		
			Both components of initial speed Horiz $31\cos 20°$ (29.1) Vert $31\sin 20°$ (10.6)	B1	No credit if sin-cos interchanged The components may be found anywhere in the question
			Time to goal $= \dfrac{50}{31\cos 20°}$	M1	Attempt to use horizontal distance ÷ horizontal speed
			$= 1.716$ ... s	A1	
			$h = 31 \times \sin 20° \times 1.716 + 0.5 \times (-9.8) \times (1.716)^2$	M1	Use of one (or more) formula(e) to find the required result(s) relating to vertical motion within a correct complete method. Finding the maximum height is not in itself a complete method.
			$h = 3.76$ (m)	A1	Allow 3.74 or other answers that would round to 3.7 or 3.8 if they result from premature rounding
			So the ball goes over the crossbar	E1	Dependent on both M marks. Allow follow through from previous answer
			Or		
			Both components of initial speed	B1	May be found anywhere in the question. No credit if sin-cos interchange
			$h = 31\sin 20° \times t - 4.9t^2$	M1	
			Substitute $h = 2.44 \Rightarrow t = (0.26 \text{ or}) \ 1.90$	A1	If only 0.26 is given, award A0
			Substitute $t = 1.90$ in $x = 31\cos 20° \times t$	M1	Allow this mark for substituting $t = 0.26$
			$x = 55.4$	A1	Allow $x = 7.6$ following on from $t = 0.26$
			Since $55.4 > 50$ the ball goes over the crossbar	E1	Dependent on both M marks. Allow FT from their value for 55.4.
			Or		
			Both components of initial speed	B1	May be found anywhere in the question. No credit if sin-cos interchanged
			$h = 31\sin 20° \times t - 4.9t^2$	M1	
			Substitute $h = 2.44 \Rightarrow t = (0.26 \text{ or}) \ 1.90$	A1	
			Time to goal $= \dfrac{50}{31\cos 20°}$	M1	Attempt to use horizontal distance ÷ horizontal speed
			$= 1.716$ ... s	A1	
			Since $1.90 > 1.72$ the ball goes over the crossbar	E1	Dependent on both M marks. Allow follow through from previous answer

Question			Answer	Marks	Guidance
			Or		
			Use of the equation of the trajectory	M1	
			$y = x\tan 20° - \dfrac{9.8x^2}{2\times 31^2 \times \cos^2 20°}$	A1	Correct substitution of $\alpha = 20°$
				A1	Fully correct
			Substituting $x = 50$	M1	
			$\Rightarrow y = 3.76$	A1	
			So the ball goes over the crossbar	E1	Dependent on both M marks. Follow through from previous answer
6	(ii)		Any one reasonable statement	B1 **[1]**	**Accept** The ground is horizontal The ball is initially on the ground Air resistance is negligible Horizontal acceleration is zero The ball does not swerve There is no wind The particle model is being used The value of g is 9.8 **Do not accept** g is constant

Question			Answer	Marks	Guidance
7	(i)		Total mass of train $= 800\ 000$ kg	B1	Allow 800 (tonnes)
			Total resistance $= 5R + 17R (= 22R)$	B1	
			Newton's 2nd Law in the direction of motion	M1	The right elements must be present, consistent with the candidate's answers above for total resistance and mass . No extra forces.
			$121\ 000 - 22R = 800\ 000 \times 0.11$		
			$22R = 121\ 000 - 88\ 000 \quad R = 1500$	E1	Perfect answer required
				[4]	
7	(ii)	(*A*)	**Either** (Last truck)		
			Resultant force on last truck $= 40\ 000 \times 0.11$	B1	Award this mark for $40\ 000 \times 0.11$ (= 4400) or 40×0.11 seen
			Use of Newton's 2nd Law	M1	The right elements must be present and consistent with the answer above; no extra forces.
			$T - 1500 = 40\ 000 \times 0.11$	A1	Fully correct equation, or equivalent working
			$T = 5900$ The tension is 5900 N.	A1	Cao
					Special case Award SC2 to a candidate who, instead, provides a perfect argument that the tension in the penultimate coupling is 11 800 N.
			Or (Rest of the train)		
			Resultant force on rest of train $= 760\ 000 \times 0.11$	B1	Award this mark for $760\ 000 \times 0.11$ (= 83 600) or 760×0.11 seen
			Use of Newton's 2nd Law	M1	The right elements must be present consistent with the answer above; no extra forces.
			$121000 - 31500 - T = 760000 \times 0.11$	A1	Fully correct equation, or equivalent working
			$T = 5900$ The tension is 5900 N.	A1	Cao
				[4]	

Question			Answer	Marks	Guidance
7	(ii)	(*B*)	**Either** (Rest of the train)		
			Newton's 2nd Law is applied to the trucks	M1	The right elements must be present; no extra forces
			$S - 25\ 500 = 680\ 000 \times 0.11$	A1	
			$S = 100\ 300$ The tension is 100 300 N.	A1	Cao
			Or (Locomotive)		
			Newton's 2nd Law is applied to the locomotive	M1	The right elements must be present; no extra forces
			$121\ 000 - S - 5 \times 1500 = 120\ 000 \times 0.11$	A1	
			$S = 100\ 300$ The tension is 100 300 N.	A1	Cao
			Or (By argument)		
			Each of the 17 trucks has the same mass, resistance and acceleration.	M1	
			So the tension in the first coupling is 17 times that in the last coupling	A1	
			$T = 17 \times 5900 = 100\ 300$	A1	Cao. For this statement on its own with no supporting argument allow SC2
				[3]	
7	(iii)		Resolved component of weight down slope		
			$= 800\ 000 \times 9.8 \times \frac{1}{80}$	B1	$m \times 9.8 \times \frac{1}{80}$ where m is the mass of the object the candidate is considering. Do not award if g is missing. Evaluation need not be seen
			$= 98\ 000$ N		
			Let the acceleration be a m s^{-2} up the slope.		
			Newton's 2nd Law to the whole train,	M1	The right elements must be present consistent with the candidate's component of the weight down the slope. No extra forces allowed
			$121\ 000 - 33\ 000 - 98\ 000 = 800\ 000a$	A1	
			$a = -0.0125$	A1	Cao but allow an answer rounding to –0.012 or -0.013 following earlier premature rounding.
			Magnitude 0.0125 m s^{-2}, down the slope		The negative sign must be interpreted so "Down the slope" or "decelerating" must be seen
				[4]	

Question			Answer	Marks	Guidance
7	(iv)		Taking the train as a whole, Force down the slope = Resistance force $800\ 000 \times 9.8 \times \sin\beta = 33\ 000$ $\beta = 0.24°$	M1 A1 A1 **[3]**	Equilibrium of whole train required The evidence for this mark may be obtained from a correct force diagram Allow missing g for this mark only
8	(i)		A: $t = 0$, $\mathbf{r} = \begin{pmatrix}3\\2\end{pmatrix}$, B: $t = 2$, $\mathbf{r} = \begin{pmatrix}15\\18\end{pmatrix}$ $\begin{pmatrix}15\\18\end{pmatrix} - \begin{pmatrix}3\\2\end{pmatrix} = \begin{pmatrix}12\\16\end{pmatrix}$ $\sqrt{12^2 + 16^2} = 20$ The distance AB is 20 km.	B1 B1 B1 **[3]**	Award this mark automatically if the displacement is correct Finding the displacement. Follow through from position vectors for A and B Cao
8	(ii)		$\mathbf{v} = \frac{d\mathbf{r}}{dt} = \begin{pmatrix}6\\8\end{pmatrix}$ which is constant	B1 **[1]**	Any valid argument. Accept $\begin{pmatrix}6\\8\end{pmatrix}$ with no comment. Do not accept $a = 0$ without explanation.
8	(iii)			B1 B1 B1 **[3]**	Points A and B plotted correctly, with no FT from part (i), and the line segment AB for the *Rosemary*. No extra lines or curves. For the *Sage*, a curve between A and B. B0 for two line segments. Nothing extra. No FT from part (i). Passes through (9, 6) Condone no labels

Question			Answer	Marks	Guidance
8	(iv)		The race is a draw.	B1 **[1]**	Cao. Accept "Both arrive at B at $t = 2$."
8	(v)		For the *Sage*, $\mathbf{v} = \frac{d\mathbf{r}}{dt} = \begin{pmatrix} 6 \\ 8t \end{pmatrix}$	M1	Attempt to differentiate **r**
			When $t = 2$, $\mathbf{v} = \begin{pmatrix} 6 \\ 16 \end{pmatrix}$	A1	Substitution
			Speed $= \sqrt{6^2 + 16^2}$	M1	Use of Pythagoras Must be on components of velocity. Allow FT from their **v** but not from displacement (etc)
			Speed $= 17.1$ (km h^{-1})	A1	
			$\tan\theta = \frac{6}{16}$	M1	Use of trig on components of their **v**
			$\Rightarrow \theta = 20.556...°$ The bearing is 21° to the nearest degree	A1 **[6]**	Condone no rounding
8	(vi)		Displacement $= \begin{pmatrix} 3+6t \\ 2+8t \end{pmatrix} - \begin{pmatrix} 3(2t+1) \\ 2(2t^2+1) \end{pmatrix}$	M1	Use of subtraction to find displacement
			$= \begin{pmatrix} 0 \\ 8t - 4t^2 \end{pmatrix}$	A1	
			Distance, $s = 8t - 4t^2$ $\quad \frac{ds}{dt} = 8 - 8t$		
			For maximum s, $\frac{ds}{dt} = 0$,		
			giving $t = 1$ (and $s = 4$)	B1	Valid method for maximising s. $t = 1$ must be seen. Allow an argument based on the graph.
			Greatest distance between the boats is 4 (km)	B1 **[4]**	Correct answer only but no preceding working need be seen The answer must be given as a scalar (ie distance and not displacement)

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