GCE

Mathematics (MEI)

Advanced GCE

Unit **4762:** Mechanics 2

Mark Scheme for January 2011

Marking instructions for GCE Mathematics (MEI): Mechanics strand

1.   You are advised to work through the paper yourself first. Ensure you familiarise yourself
      with the mark scheme before you tackle the practice scripts.

2.   You will be required to mark ten practice scripts. This will help you to understand the
      mark scheme and will not be used to assess the quality of your marking. Mark the scripts
      yourself first, using the annotations. Turn on the comments box and make sure you
      understand the comments. You must also look at the definitive marks to check your
      marking. If you are unsure why the marks for the practice scripts have been awarded in the
      way they have, please contact your Team Leader.

3.   When you are confident with the mark scheme, mark the ten standardisation scripts. Your
      Team Leader will give you feedback on these scripts and approve you for marking. (If your
      marking is not of an acceptable standard your Team Leader will give you advice and you
      will be required to do further work. You will only be approved for marking if your Team
      Leader is confident that you will be able to mark candidate scripts to an acceptable
      standard.)

4.   Mark strictly to the mark scheme. If in doubt, consult your Team Leader using the
      messaging system within *scoris*, by email or by telephone. Your Team Leader will be
      monitoring your marking and giving you feedback throughout the marking period.

      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.

5.   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.

6. 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.

7. 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.

8. 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 metre 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 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.

9.   **Rules for crossed out and/or replaced work**

If work is crossed out and not replaced, examiners should mark the crossed out work if it is legible.

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 two or more attempts are made at a question, and just one is not crossed out, examiners should ignore the crossed out work and mark the work that is not crossed out.

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.

10.   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 of 1 mark is generally appropriate and 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.

11.	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.
12.	If in any case the scheme operates with considerable unfairness consult your Team Leader.

13.	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.

14. For answers scoring no marks, you must either award NR (no response) or 0, as follows:

Award NR (no response) if:
- Nothing is written at all in the answer space
- There is a comment which does not in any way relate to the question being asked ("can't do", "don't know", etc.)
- There is any sort of mark that is not an attempt at the question (a dash, a question mark, etc.)

The hash key [#] on your keyboard will enter NR.

Award 0 if:
- There is an attempt that earns no credit. This could, for example, include the candidate copying all or some of the question, or any working that does not earn any marks, whether crossed out or not.

15. The following abbreviations may be used in this mark scheme.

M1   method mark (M2, etc, is also used)
A1   accuracy mark
B1   independent mark
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
ft   follow through
isw   ignore subsequent working
oe   or equivalent
rot   rounded or truncated
sc   special case
soi   seen or implied
www   without wrong working

16. Annotating scripts. The following annotations are available:

✓ and ✗
BOD   Benefit of doubt
FT   Follow through
ISW   Ignore subsequent working (after correct answer obtained)
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 is also available to highlight any particular points on a script.
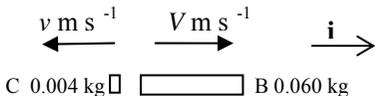
17. The comments box will be used by the Principal Examiner to explain his or her marking of the practice scripts for your information. Please refer to these comments when checking your practice scripts.

    Please do not type in the comments box yourself. Any questions or comments you have for your Team Leader should be communicated by the *scoris* messaging system, e-mail or by telephone.

18. Write a brief report on the performance of the candidates. Your Team Leader will tell you when this is required. The Assistant Examiner's Report Form (AERF) can be found on the Cambridge Assessment Support Portal. This should contain notes on particular strengths displayed, as well as common errors or weaknesses. Constructive criticisms of the question paper/mark scheme are also appreciated.

19. Link Additional Objects with work relating to a question to those questions (a chain link appears by the relevant question number) – see scoris assessor Quick Reference Guide page 19-20 for instructions as to how to do this – this guide is on the Cambridge Assessment Support Portal and new users may like to download it with a shortcut on your desktop so you can open it easily! For AOs containing just formulae or rough working not attributed to a question, tick at the top to indicate seen but not linked. When you submit the script, *scoris* asks you to confirm that you have looked at all the additional objects. Please ensure that you have checked all Additional Objects thoroughly.

20. The schedule of dates for the marking of this paper is displayed under 'OCR Subject Specific Details' on the Cambridge Assessment Support Portal. It is vitally important that you meet these requirements. If you experience problems that mean you may not be able to meet the deadline then you must contact your Team Leader without delay.

Q 1		mark	notes
(i)	Let normal reaction be R $\sin\alpha = \sqrt{1-0.8^2} = 0.6$ $R = 2.5 \times 9.8 \times 0.8$ $F_{max} = 0.85 \times R = 16.66$ Wt cpt down slope is $2.5 \times 9.8 \times 0.6 = 14.7$ $16.66 > 14.7$ so at rest	B1 M1 B1 F1 B1 E1	Accept any form and implied Use of $F_{max} = \mu R$ Expression for R; may be implied FT their R FT if their F and weight component show given result If g omitted, allow B1M1B0F1B0E1, so 4/6 [Award as follows for use of $\tan\alpha < \mu$: B1 $\tan\alpha = \dfrac{3}{4}$ E1 $\tan\alpha < \mu$ shown]
		6	
(ii)	Let the speeds down the plane be v_A and v_B. PCLM down the plane $1.5 \times 16 = 2.5v_A + 1.5v_B$ so $5v_A + 3v_B = 48$ NEL +ve down the plane $\dfrac{v_A - v_B}{0-16} = -0.4$ $v_A - v_B = 6.4$ $v_A = 8.4$ so 8.4 m s^{-1} down plane $v_B = 2$ so 2 m s^{-1} down plane	M1 A1 M1 A1 E1 F1	PCLM Any form NEL. Allow sign errors Any form Condone direction not clear if +8.4 seen Condone direction not clear if +2 seen. SC1 if 2 equations obtained and 8.4 substituted into one to obtain answer 2 (instead of E1F1)
		6	
(iii)	$1.5 \times (2-16)$ down plane $= -21$ N s down the plane so 21 Ns up the plane	M1 A1 A1	Use of $m(\mathbf{v}-\mathbf{u})$ If impulse on A found, treat as MR unless final answer relates this to impulse on B ± 21 N s Direction explicitly commented on
		3	

Q 1		mark	notes
(iv)	**either**		
	$(2.5 \times 9.8 \times 0.6 - F_{max}) \times t = 2.5(0 - 8.4)$	M1	Using Impulse-momentum (must use 8.4) . sufficient to consider one term on LHS
		B1	Either side correct
		A1	Allow only sign errors
	so $t = 10.7142\ldots$ 10.7 s (3 s. f.)	A1	cao
	or		
	Using N2L down the plane	M1	Using N2L ; sufficient to consider one force term
	$a = -0.784$	A1	Allow sign errors
		M1	Using appropriate *suvat* must use *a* or-*a* found by use of N2L and *u* = 8.4
	using $v = u + at$, $t = 10.7142\ldots$ 10.7 s (3 s. f.)	A1	cao
	or		
	$0.5 \times 2.5 \times 8.4^2 + (14.7 - 16.66)x = 0$	M1	Use energy with 8.4, sufficient to consider one non-KE term
	$x = 45$	A1	
		M1	Using appropriate *suvat*
	$T = 10.7142\ldots..$ 10.7 (3 s. f.)	A1	cao
		4	
		19	

Q 2		m a r k	notes
(a)	v m s^{-1} V m s^{-1} **i**		
	C 0.004 kg B 0.060 kg		
	Energy: $\frac{1}{2} \times 0.004 \times v^2 + \frac{1}{2} \times 0.060 \times V^2 = 0.8$	M1	Use of KE in two terms in an equation.
	$v^2 + 15V^2 = 400$	A1	Any form
	PCLM in **i** direction: $0.06V - 0.004v = 0$	M1	PCLM. Accept sign errors.
	$v = 15V$	A1	Any form
	Solving	M1	Valid method for elimination of v or V from a linear and a quadratic
	$(15V)^2 + 15V^2 = 400$		
	so $V^2 = \frac{400}{240} = \frac{5}{3}$ and $\mathbf{V} = \sqrt{\frac{5}{3}}\mathbf{i}$	A1	Accept 1.29099…**i** Accept no direction
	$\mathbf{v} = -15\sqrt{\frac{5}{3}}\mathbf{i} \ (= -\sqrt{375}\mathbf{i})$	F1	Accept – 19.3649…**i** Accept no direction Second answer follows from first
		A1	(Relative) directions indicated - accept diagram. Both speeds correct.
		8	
(b)(i)	W is work done by resistances on car		
	$\frac{1}{2} \times 800 \times (12^2 - 30^2) = -800 \times 9.8 \times 20 + W$	M1	Use of WE. Must have KE, W and GPE. Allow -W
		B1	Both KE terms. Accept sign error
		A1	All correct with W or -W
	W = – 145 600		
	so 145 600 J done by car against resistances	A1	cao
		4	

Q 2		mark	notes
(ii)	**either** The slope is $18 \times 25 = 450$ m long	B1	
	$$\dfrac{800 \times 9.8 \times 20 + 750 \times 450}{25}$$	M1	Use of P = (Work done) / (elapsed time) used for at least one work done term
		M1	WD is force × distance used for at least one force
		A1	Allow only sign errors both terms
	$= 19\ 772$ W	A1	cao.
	or The angle of the slope is arcsin (1/22.5)	B1	
	$$\left(800 \times 9.8 \times \dfrac{1}{22.5} + 750\right) \times 18$$	M1	Use of $P = Fv$ used for at least one term
		M1	Attempt at weight component
		A1	Allow only sign errors both terms
	$= 19\ 772$ W	A1	cao.
		5	
		17	

Q 3		mark	notes
(i)	Horizontal $X - 50 = 0$ Vertical: $R - Y - 45 = 0$	B1 B1 2	Any form Any form
(ii)	a. c. moments about A $1 \times R = 3 \times 45$ so $R = 135$ so $135 - Y - 45 = 0$ and $Y = 90$	M1 E1 E1 3	 Clearly shown Shown
(iii)	In analysis below all internal forces are taken as tensions	B1 B1 2	Correct arrow pairs for all internal forces Correct labels

Q 3		mark	notes
(iv)		M1	Equilibrium attempted at a pin-joint
		M1	Equilibrium attempted at a 2nd pin-joint
		M1	Either Equilibrium equation for 2nd direction at a pin-joint or 3rd pin-joint considered
	At C	B1	At least 3 equations of resolution correct or follow through
	$\uparrow \quad T_{CD}\cos 30 - 45 = 0$ so $T_{CD} = 30\sqrt{3}$		
	and force in CD is $30\sqrt{3}$ N (T)	A1	
	$\leftarrow \quad T_{BC} + T_{CD}\cos 60 = 0$ so $T_{BC} = -15\sqrt{3}$		
	and force in BC is $15\sqrt{3}$ N (C)	F1	
	At D		
	$\downarrow \quad T_{BD}\cos 30 + T_{CD}\cos 30 = 0$		
	so $T_{BD} = -30\sqrt{3}$		
	and force in BD is $30\sqrt{3}$ N (C)	F1	
	$\leftarrow \quad T_{AD} + T_{BD}\cos 60 - T_{CD}\cos 60 - 50 = 0$		
	so $T_{AD} = 50 + 30\sqrt{3}$		
	and the force in AD is $50 + 30\sqrt{3}$ N (T)	F1	
	At A		
	$\downarrow \quad T_{AB}\cos 30 + 90 = 0$ so $T_{AB} = -60\sqrt{3}$		
	and the force in AB is $60\sqrt{3}$ N (C)	F1	
		B1	At least 4 T/C correct
		10	
(v)	The equilibria at C depend only on the framework geometry and the 45 N.	E1	Resolve in two directions at *C* and obtain same results as in (iv) M1A1
	These are not changed so forces in CB and CD are not changed	E1	
		2	
		19	

Q 4		m a r k	notes
(i)	(2, 2.5)	B1 1	Condone writing as a vector
(ii)	By symmetry, $\overline{y} = 2.5$ For $\overline{x}$: $\left(5h + \dfrac{1}{2} \times 5 \times 6\right)\overline{x} = 5h \times \left(-\dfrac{h}{2}\right) + \dfrac{1}{2} \times 5 \times 6 \times 2$ so $(5h + 15)\overline{x} = -2.5h^2 + 30$ so $5(h + 3)\overline{x} = 2.5(12 - h^2)$ and $\overline{x} = \dfrac{12 - h^2}{2(h + 3)}$	B1 M1 A1 A1 A1 E1 6	Some justification needed These next 4 marks may be obtained from correct FT of their "2" from (i) 1st term RHS correct (allow sign error) Either other term correct All correct Clearly shown, including signs.
(iii)	Need $\overline{x} > 0$ So $\dfrac{12 - h^2}{2(h + 3)} > 0$ Hence $12 - h^2 > 0$ Since $h > 0$, $0 < h < 2\sqrt{3}$	M1 B1 A1 3	Allow $\overline{x} \geq 0$ or = 0 $2\sqrt{3}$ or $-2\sqrt{3}$ oe seen Accept only +ve root mentioned. WWW for signs Accept $h < 2\sqrt{3}$ as answer strict inequality for final A mark

Q 4		m a r k	notes
Q4 (iv)	**continued** When $h = 3$, $\bar{x} = 0.25$ Let mag of vert force be T N a.c moments about axis thro' O $T \times 6 - 15 \times 0.25 = 0$ so $T = 0.625$ so 0.625 N	B1 M1 A1 3	Could be scored in (v) If moments about another point need all relevant forces. Allow sign errors. Condone use of $15g$ cao
(v)	Let magnitude of force be U N a.c. moments about axis thro' D $U \cos 30 \times 5 - 15 \times (3 + 0.25) = 0$ $U = 11.25833\ldots$ so 11.3 N (3 s. f.)	M1 B1 A1 A1 4	Each term must be a moment. If moments about another point need all relevant forces. Condone use of $15g$. moment of U ($5U\cos 30$ or …) oe $(3 + 0.25)$ oe cao
		17	