



GCE

Mathematics (MEI)

Advanced GCE

Unit 4762: Mechanics 2

Mark Scheme for January 2011

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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.

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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..

It 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. | <p>Annotations should be used whenever appropriate during your marking.</p> <p>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.</p> |

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.

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Mark Scheme

January 2011

| Q 1 | | m a r k | notes |
|-------|---|----------------------------------|--|
| (i) | <p>Let normal reaction be R $\sin \alpha = \sqrt{1 - 0.8^2} = 0.6$</p> <p>$R = 2.5 \times 9.8 \times 0.8$ $F_{\max} = 0.85 \times R = 16.66$</p> <p>Wt cpt down slope is $2.5 \times 9.8 \times 0.6 = 14.7$ $16.66 > 14.7$ so at rest</p> | 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 $\tan \alpha = \frac{3}{4}$ E1 $\tan \alpha < \mu$ shown] |
| | | 6 | |
| (ii) | <p>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 $\frac{v_A - v_B}{0 - 16} = -0.4$ $v_A - v_B = 6.4$ $v_A = 8.4$ so 8.4 m s^{-1} down plane $v_B = 2$ so 2 m s^{-1} down plane</p> | 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) | <p>$1.5 \times (2 - 16)$ down plane $= -21 \text{ N s}$ down the plane so 21 N s up the plane</p> | M1 A1 A1 3 | Use of $m(v - u)$ If impulse on A found, treat as MR unless final answer relates this to impulse on B $\pm 21 \text{ N s}$ Direction explicitly commented on |

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Mark Scheme

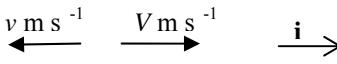
January 2011

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

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

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Mark Scheme

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

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| Q 3 | | m a r k | 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 |

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Mark Scheme

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

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

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| Q 4 | | m a r k | notes |
|-------------------|--|--|---|
| Q4 (iv) | <p>continued</p> <p>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</p> | <p>B1</p> <p>M1</p> <p>A1</p> <p>3</p> | <p>Could be scored in (v)</p> <p>If moments about another point need all relevant forces. Allow sign errors. Condone use of 15g cao</p> |
| (v) | <p>Let magnitude of force be U N a.c. moments about axis thro' D $U \cos 30 \times 5 - 15 \times (3 + 0.25) = 0$ $U = 11.25833\dots$ so 11.3 N (3 s. f.)</p> | <p>M1</p> <p>B1</p> <p>A1</p> <p>A1</p> <p>4</p> | <p>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</p> |
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