Comparison of key skills specifications 2000/2002 with 2004 standardsX015461July 2004Issue 1

Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE

In Mathematics (9MA0)

Paper 32 Mechanics

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**General Marking Guidance**

* All candidates must receive the same treatment.  Examiners must mark the first candidate in exactly the same way as they mark the last.
* Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
* Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
* There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
* All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme.  Examiners should also be prepared to award zero marks if the candidate’s response is not worthy of credit according to the mark scheme.
* Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
* When examiners are in doubt regarding the application of the mark scheme to a candidate’s response, the team leader must be consulted.
* Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

**EDEXCEL GCE MATHEMATICS**

**General Instructions for Marking**

1. The total number of marks for the paper is 50.
2. The Edexcel Mathematics mark schemes use the following types of marks:
* **M** marks: method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
* **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
* **B** marks are unconditional accuracy marks (independent of M marks)
* Marks should not be subdivided.
1. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

* bod – benefit of doubt
* ft – follow through
* the symbol will be used for correct ft
* cao – correct answer only
* cso - correct solution only. There must be no errors in this part of the question to obtain this mark
* isw – ignore subsequent working
* awrt – answers which round to
* SC: special case
* oe – or equivalent (and appropriate)
* dep – dependent
* indep – independent
* dp decimal places
* sf significant figures
* 🞸 The answer is printed on the paper
* The second mark is dependent on gaining the first mark
1. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
2. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.

If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

1. Ignore wrong working or incorrect statements following a correct answer.
2. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

**General Principles for Mechanics Marking**

*(But note that specific mark schemes may sometimes override these general principles)*

* Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
* Omission or extra g in a resolution is an accuracy error not method error.
* Omission of mass from a resolution is a method error.
* Omission of a length from a moments equation is a method error.
* Omission of units or incorrect units is not (usually) counted as an accuracy error.
* DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
* Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
* Use of g = 9.81 should be penalised once per (complete) question.

N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.

* Marks must be entered in the same order as they appear on the mark scheme.

* In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
* Accept column vectors in all cases.
* Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
* Mechanics Abbreviations

M(A) Taking moments about A.

N2L Newton’s Second Law (Equation of Motion)

NEL Newton’s Experimental Law (Newton’s Law of Impact)

HL Hooke’s Law

SHM Simple harmonic motion

PCLM Principle of conservation of linear momentum

RHS, LHS Right hand side, left hand side.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **1(a)** | Put *t* = 2 in **v** and use Pythagoras:   | M1 | 3.1a |
|  or 15 or better ()  | A1 | 1.1b |
|  | **(2)** |  |
| **1(b)** | Differentiate **v** wrt *t* to obtain **a** | M1 | 3.4 |
|  oe () isw | A1 | 1.1b |
|  | **(2)** |  |
| **1(c)** | Integrate **v** wrt *t* to obtain **r** | M1 | 3.4 |
|  **r** =   | A1 | 1.1b |
|   | M1 | 3.1a |
|  (m) isw e.g. if they go on to find the distance. | A1 | 1.1b |
|  | **(4)** |  |
| **(8 marks)** |
| **Notes: Accept column vectors throughout apart from the answer to (b).** |
|  **1a** | M1 | Need square root but -ve sign not required. Allow **i**’s and/or **j**’s to go missing from their **v** at *t* = 2, provided they have applied Pythagoras correctly. |
|  | A1 | cao **N.B**. Correct answer with no working can score 2 marks. |
| **1b** | M1 | Both powers decreasing by 1. Allow a column vector.M0 if **i** or **j** is missing but allow recovery in (b). |
|  | A1 | cao. Do not accept a column vector. |
| **1c** | M1 | Both powers increasing by 1M0 if **i** or **j** is missing but allow recovery. |
|  | A1 | (**r** = ) not required |
|  | M1 | Putting **r** = and *t* = 4 into their displacement **vector** expression which must have **C** (allow *C***)** to give an equation in **C** only, seen or implied.Must have attempted to integrate **v** for this mark to be available.**N.B**. **C** does not need to be found and this is a method mark, so allow slips. |
|  | A1 | cao  |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **2(a)(i)** | Resolve vertically | M1 | 3.1b |
|  *F* acting UP the plane: **OR**  *F* acting DOWN the plane:  Other possible equations from which *X* would need to be eliminated to give an equation in *F* **only** to earn the M mark are shown below. The equation in *F* **only** must then be correct to earn the A mark.Possible equations: (leads to *X* = 49 with *g* = 9.8) *F* acting UP the plane: **OR**  *F* acting DOWN the plane:       | A1 | 1.1b |
| 9.8 (N) (49/5 is A0)**N.B.** If sin and cos are interchanged in all equations, this leads to an answer of 9.8 in the wrong direction and can only score (a) (i)M1A0A0 (ii) A0 | A1 | 1.1b |
|  | **(3)** |  |
| **2(a)(ii)** | Down the plane (Allow down or downwards or an arrow , but must appear as the answer to (a) (ii) not just on the diagram.) | A1 | 2.2a |
|  | **(1)** |  |
| **2(b)** | **N.B.** If they use *R* = 68.6 in this part, the maximum they can score is M1A1M0A0M0A0If they use *F* = 9.8 or their *F* from (a) in this part, the maximum they can score is M1A1M0A0M0A0 |  |  |
|  | Equation of motion down the plane | M1 | 2.1 |
| Allow (-*a*) instead of *a* | A1 | 1.1b |
| Resolve perpendicular to the plane | M1 | 3.1b |
|   | A1 | 1.1b |
|  seen | M1 | 3.4 |
| *a* = 1.96 or 2.0 or 2 () or   | A1 | 1.1b |
|  | **(6)** |  |
| **(10 marks)** |
| **Notes:**  |
| **2a****(i)** | M1 | Complete method to obtain an equation in *F* **only.**For **each** equation used, correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved. |
|  | A1 | Correct equation in *F* only, trig does **not** need to be substituted |
|  | A1 | cao (must be **positive**) |
| **2a****(ii)** | A1 | cao. Note that this mark is **dependen**t on an answer of 9.8 or -9.8 for (a)(i) from a fully correct solution unless they have used *g* = 9.81, in which case the answer will be 9.7 or – 9.7 (2sf) see **SC2** below.**N.B.** Allow this mark, if their answer to (a)(i) is fully correct apart from a small error due to use of inaccurate trig i.e using an angle 36.9o |
|  |  | **SC 1:** If they use  at any point (with an unknown ) for *F* in part (a), can score  (a)(i) max M1A1A0  (a) (ii) A1, where they must have obtained = 9.8 or – 9.8, **from correct working**.**SC 2:** **If *g* = 9.81 is used consistently throughout 2(a)**, (leading to *X* = 48.9…and *F* = 9.7 (2sf)) can score max (a)(i) M1A1A0 (a)(ii) A1 |
| **2b** | M1 | Correct no.of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved. |
|  | A1 | Correct equation **for their *F***. |
|  | M1 | Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved.(**N.B.** M0 if *R* = 68.6 (N) is used in this equation) |
|  | A1 | Correct equation |
|  | M1 | Could be seen on a diagram (**N.B**. M0 if *R* = 68.6 (N) is used) |
|  | A1 | Cao. **Must be positive**. |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **3(a)** | +=   | M1 | 3.4 |
| Use **ratios** to obtain an equation in and *only*  | M1 | 2.1 |
|  or   | A1 | 1.1b |
| \* Allow  but nothing else. | A1\* | 1.1b |
|  | **(4)** |  |
| **(b)** |  = 2 =>  = 3 ; Resultant force = (N) | M1 | 3.1a |
| = 4**a****OR**    | M1 | 1.1b |
| Use of  with **u** = **0**, their **a** and *t* = 4 :**Or** they may integrate their **a** twice with **u** = **0** and put *t* = 4 :=  | DM1 | 2.1 |
|   | M1 | 1.1b |
| **ALTERNATIVE 1**  for last two M marks:Use of , with *u* = 0, their *a* and *t* = 4 : DM1*s* =  Use of Pythagoras to find mag of **a** :*a* **=**  M1 |  |  |
| **ALTERNATIVE 2**  for last two M marks:Use of , with *u* = 0, their *a* and *t* = 4 : DM1*s* =  Use of Pythagoras to find :  **=**  M1 |  |  |
| , oe or 13 or better (m)  | A1 | 1.1b |
|  | **(5)** |  |
| **(9 marks)** |
| **Notes: Accept column vectors throughout** |
| **3a** | M1 | Adding the two forces, **i**’s and **j**’s must be collected (or must be a **single** column vector) seen or implied |
|  | M1 | Must be using ratios; Ignore an equation e.g.  if they go on to use ratios.However, if they write  then 3() = 3 so = 3() with no use of a constant, it’s M0They may use the acceleration, with a factor of top and bottom, see alternative**Allow one side of the equation to be inverted** |
|  | A1 | Correct equation |
|  | A1\* | Given answer correctly obtained. Must see at least one line of working, with the LH fraction ‘removed’**.** |
| **3b** | M1 | Adding to find the resultant force, must be substituted**N.B.** M0 if they use coming from  in part (a).  |
|  | M1 | Use of **F** = 4**a** Or , where **F** is their resultant. (including 3**i** + **j**)This is an independent mark, so could be earned, for example, if they have subtracted the forces to find the ‘resultant’**N.B.** M0 if only using   |
|  | DM1 | Dependent on previous M mark for**Either**: use of  with **u** = **0**, their **a** and *t* = 4 to produce a displacement vector**Or** : integrate twice, with **u** = **0**, their **a** and *t* = 4 to produce a displacement Vector**Or**: use of  with *u* = 0, their *a* and *t* = 4 to produce a length |
|  | M1 | Use of Pythagoras, with square root, to find the magnitude of their displacement vector, **a** or **F (**M0 if only using ) depending on which method they have used. |
|  | A1 | cao |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)** | The horizontal component of *T* acts to the left and since the **only** other horizontal force is friction, it must act to the right oe | B1 | 2.4 |
|  | **(1)** |  |
| **4(b)** | Take moments about *A* or any other complete method to obtain **an equation in *T*, *M* and  only.** (see possible equations below that they may use) | M1 | 3.1b |
|  (A0 if *a*’s missing) | A1 | 1.1b |
| Other possible equations but *F* and *R* would need to be eliminated.  |  |  |
| \*  | A1\* | 1.1b |
|  | **(3)** |  |
| **4(c)** | e.g. Resolve vertically | M1 | 3.4 |
|   | A1 | 1.1b |
| \*  | A1\* | 1.1b |
|  | **(3)** |  |
| Other possible equations but *F* would need to be eliminated.  |  |  |
|  |  |  |
| **4(d)** | Find an equation containing *F* e.g. Resolve horizontally | M1 | 3.4 |
|  |   | A1 | 1.1b |
|  | Other possible equations |  |  |
|  | used i.e. both *F* and *R* are substituted. | M1 |  3.1b |
|  |  \* | A1\* | 2.2a |
|  |  | **(4)** |  |
| **(11 marks)** |
| **Notes:** |
|  **4a** | B1 | Any equivalent explanation |
|  **4b** | M1 | Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors |
|  | A1 | Correct equation, trig does not need to be substituted(Allow: ) |
|  | A1\* | Given answer correctly obtained with no wrong working seen. Allow  But not   |
| **4c** | M1 | For an equation in *R*, *M*, *T* and  **only**Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved |
|  | A1 | Correct equation, *T* and trig do not need to be substituted |
|  | A1\* | Given answer correctly obtained with no wrong working seen  |
| **4d** | M1 | For any equation with *F* in itCorrect no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved |
|  | A1 | Correct equation, trig does not need to be substituted |
|  | M1 | Must be used i.e M0 if merely quoting it. |
|  | A1\* | Given answer correctly obtained with no wrong working seen |
|  |  |  |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **5(a)** | Using horizontal motion | M1 | 3.3 |
| **Whole Motion Half way** |  |  |
|      | A1 | 1.1b |
| Using vertical motion **OR** | M1 | 3.4 |
|     | A1 | 1.1b |
| Attempt to solve problem by eliminating *t*  | DM1 | 3.1b |
| \* | A1\* | 2.2a |
|  | **(6)** |  |
|  | **N.B.** No credit given if they use the given answer from (b). |  |  |
| **5(b)** | Using vertical motion **OR** conservation of energy  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | **ALTERNATIVE 1:** If *t* is time to top: use of oe ( *t* = ) to obtain an equation in *U* and only M1 or  A1 **ALTERNATIVE 2:** If *t* is time to top: use of :  with  substituted to obtain an equation in *U* and only : M1 A1   |  |  |
|  | Attempt to solve problem by eliminating :e.g.  => , from part (a) or from using *t* = , then square and add to give result**OR:**  and , divide to give  then, hence result **OR in ALTERNATIVE 2**: sub for *U* 2 using part (a), to give  then, hence result**N.B**. Just stating that , with no working is DM0A0. | DM1 | 3.1b |
|  | \*  | A1\* | 2.2a |
|  | **N.B.** Verification (i.e. starting with  and trying to work backwards) is not an acceptable method for this question. |  |  |
|  |  | **(4)** |  |
| **5(c)** | *V ,* since air resistance has to be overcome, or just ‘because of air resistance’ isw | B1 | 3.5a |
|  | **(1)** |  |
| **5(d)** |  e.g. wind effects, more accurate value of *g,* spin of ball, size of ball, shape of ball, dimensions of ball, not a particle, variable acceleration, surface area of ball, humidity. Allow wind resistance and rotational resistance(Ignore any mention of air resistance or drag) | B1 | 3.5c |
|  | **(1)** |  |
| **(12 marks)** |
| **Notes:** |
| **5a** |  | **N.B**. Could score 2/6 for any one of the 4 given equations if there is no corresponding second equation or there is an attempt but it’s incorrect. |
|  | M1 | Complete method to give equation in *U* ,and *t* only, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved |
|  | A1 | Correct equation |
|  | M1 | Complete method to give equation in *U*, and *t* only, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved |
|  | A1 | Correct equation |
|  | DM1 | Eliminate *t* , dependent on first and second M1’s |
|  | A1\* | Given answer correctly obtained, with no wrong working seen.Allow  but nothing else |
| **5b** | M1 | Complete method to give equation in *U* and only with correct no. of terms, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved |
|  | A1 | Correct equation |
|  | DM1 | Eliminate  and rearrange, dependent on first M1 |
|  | A1\* | Given answer correctly obtained with no wrong working seen(**N.B**. If they use a value for (18.43.o.) they lose the final A1\*) |
| **5c** | B1 | Clear statement isw |
| **5d** | B1 | B0 if there is an incorrect extra e.g. mass or weight |

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