# Mark Scheme (Results)

## Summer 2024

Pearson Edexcel GCE
AS Mathematics (8MA0)
Paper 22 Mechanics

## Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

## Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2024
Question Paper Log P72841
Publications Code 8MA0_22_2406_MS*

**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 40.

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.

3. 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 $\surd$ 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

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

# 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.

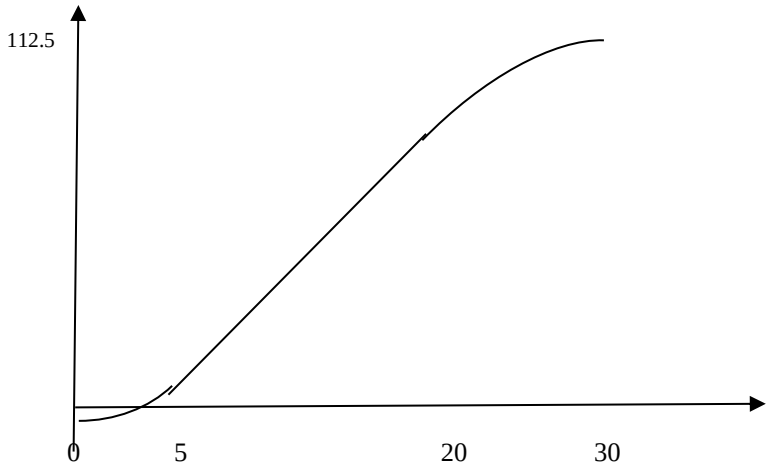
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

- 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)** | Complete method to find *AB* | M1 | 3.1b |
| | $=(\frac{1}{2}\times5\times5)+(5\times15)+(\frac{1}{2}\times5\times10)$<br>or $=\frac{1}{2}(30+15)\times5$<br>or $=(\frac{1}{2}\times5\times5)+\frac{1}{2}(25+15)\times5$<br>or $=\frac{1}{2}(20+15)\times5+(\frac{1}{2}\times5\times10)$<br>or $=(30\times5)-(\frac{1}{2}\times5\times5)-(\frac{1}{2}\times5\times10)$ | A1 | 1.1b |
| | $=112.5\,(\text{m})$ | A1 | 1.1b |
| | | **(3)** | |
| **(b)** |  | B1<br>B1<br>B1 | 1.1b<br>1.1b<br>1.1b |
| | | **(3)** | |
| | | | **(6 marks)** |

**Notes:**

| | |
|---|---|
| **(a)** | |
| **M1** | Complete method to find the total area under the graph, with the correct structure<br>triangle + rectangle + triangle<br>or trapezium<br>or triangle + trapezium<br>or trapezium + triangle<br>or rectangle – triangle – triangle<br><br>**N.B.** They may use *suvat* on one or more of the sections. |
| **A1** | Correct unsimplified expression for the distance *AB* |

| | |
|---|---|
| **A1** | Accept 110 or better |
| | |
| **(b)** | **SC**: If there is a single straight line with a positive gradient, allow B1B0B0, unless it's absolutely clear that it is for the first section only.<br>If there are just two straight lines, both with positive gradient, allow B1B0B0. |
| **B1** | One section correct. Straight section should be straight with positive gradient..Curves should look like curves with first one having increasing gradient and second one decreasing gradient but staying non-negative. |
| **B1** | Two sections correct. Straight section should be straight with positive gradient Curves should look like curves with first one having increasing gradient and second one decreasing gradient but staying non-negative. Continuous graph but condone incorrect transition between sections. |
| **B1** | All three sections correct and 5, 20, 30 and **their** 112.5 shown. Straight section should be straight with positive gradient. Curves should look like curves with first one having increasing gradient and second one decreasing gradient but staying non-negative. Continuous graph but condone incorrect transition between sections. |
| | **N.B.** Subtract 1 mark from any earned if there is a continuous vertical line at the end.<br>Ignore any figs when awarding the first two B marks except for the **SC** mentioned above. |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **2(a)** | Differentiate $2t-7\sqrt{t}+6$ wrt $t$ | M1 | 3.1a |
| | $2-\frac{7}{2\sqrt{t}}$ oe | A1 | 1.1b |
| | When $t=4$, $a=0.25(\text{m s}^{-2})$ | A1 | 1.1b |
| | | **(3)** | |
| **(b)** | Integrate $2t-7\sqrt{t}+6$ wrt $t$ | M1 | 3.1a |
| | $t^2-\frac{14}{3}t^{\frac{3}{2}}+6t(+C)$ | A1 | 1.1b |
| | Use the limits to find $XY$ | DM1 | 1.1b |
| | $(XY=)$ $\frac{1}{3}\left(41-28\sqrt{2}\right)$ (metres) * | A1* | 1.1b |
| | | **(4)** | |
| | | | **(7 marks)** |

| **Notes:** | |
|---|---|
| **(a)** | |
| **M1** | Both powers of $t$ decreasing by 1 |
| **A1** | Any equivalent form |
| **A1** | Any equivalent form |
| **(b)** | |
| **M1** | At least two powers of $t$ increasing by 1 |
| **A1** | Correct integration (accept without constant of integration and unsimplified) |
| **DM1** | Correct use of 'limits', seen or implied.<br>$\left(2^2-\frac{14}{3}\times 2^{\frac{3}{2}}+6\times 2(+C)\right)-\left(1^2-\frac{14}{3}\times 1^{\frac{3}{2}}+6\times 1(+C)\right)$<br><br>Condone missing second pair of brackets for this mark<br>**N.B.** Allow the subtraction the other way round and the use of decimals. |
| **A1*** | $=\frac{(48-28\sqrt{2})}{3}-\frac{7}{3}=\frac{(41-28\sqrt{2})}{3}$ *<br>Obtain given answer from correct working including correct use of brackets, with at least one more line of working, including a term in $\sqrt{2}$. Not available if they use decimals. |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| 3 | Resultant force $=(2+c)\mathbf{i}+(4-2)\mathbf{j}$ | B1 | 1.1b |
| | $\sqrt{(2+c)^2+2^2}$ or $(2+c)^2+2^2$ | M1 | 3.1a |
| | $(2+c)^2+4=4\times5$ or $\sqrt{(2+c)^2+2^2}=2\times\sqrt{5}$ | M1 | 3.1a |
| | **OR** | | |
| | $\mathbf{a}=\frac{1}{2}\left[(2+c)\mathbf{i}+(4-2)\mathbf{j}\right]$ oe | M1 | |
| | $\frac{1}{4}\left[(2+c)^2+4\right]=5$ or $\frac{1}{2}\sqrt{(2+c)^2+2^2}=\sqrt{5}$ | M1 | |
| | $c=2$ or $c=-6$ | A1 | 1.1b |
| | $c=2$ and $c=-6$ | A1 | 2.2a |
| | | **(5)** | |
| | | | **(5 marks)** |

| | |
|---|---|
| **Notes:** | **N.B.** Allow the use of column vectors |
| **B1** | Seen or implied, with **i**'s and **j**'s collected |
| **M1** | Using Pythagoras, with or without the root, on their resultant force<br>**N.B.** This mark is available even if they've subtracted the two forces. |
| **M1** | Use of $F = ma$ to obtain an equation in $c$ only. |
| | **OR** |
| **M1** | Using **F** = $m$**a** with their resultant force to obtain **a** with **i**'s and **j**'s collected<br>**N.B.** This mark is available even if they've subtracted the two forces. |
| **M1** | Using Pythagoras, with or without the root, on their **a** to obtain an equation in $c$ only |
| **A1** | One correct value |
| **A1** | Two correct values |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| | **N.B.** Use the mass in the *ma* term to determine which part of the system the equation refers to. | | |
| **4(a)** | Equation of motion: | M1 | 3.3 |
| | $1740-400-R=(600+800)\times 0.6$<br>Or $\begin{cases}1740-T-400=800\times 0.6\\ T-R=600\times 0.6\end{cases}$ with $T$ eliminated or found (860) from the first equation, and then used in the second to find $R$. | A1 | 1.1b |
| | $R=1740-840-400=500$ * | A1* | 2.2a |
| | | **(3)** | |
| **(b)** | Equation of motion for car or trailer | M1 | 3.4 |
| | $1740-T-400=800\times 0.6$ or $T-500=600\times 0.6$ | A1 | 1.1b |
| | $T=860$ | A1 | 1.1b |
| | | **(3)** | |
| **(c)** | Use of $500=\pm 600a$ to obtain *<br>**N.B.** Need to see explicitly deceleration $=\frac{5}{6}$ | B1* | 1.1b |
| | | **(1)** | |
| **(d)** | Complete method to find distance with $a=\pm\frac{5}{6}$ | M1 | 3.4 |
| | $0=12.5^2-2\times\frac{5}{6}\times d$<br>**OR e.g.** $t=\frac{12.5}{\frac{5}{6}}=15$ then $d=\frac{1}{2}\times\frac{5}{6}\times 15^2$ or $d=\frac{1}{2}\times(0+12.5)\times 15$<br>or $d=12.5\times 15+\frac{1}{2}\times(-\frac{5}{6})\times 15^2$ | A1 | 1.1b |
| | 93.75 oe | A1 | 1.1b |
| | | **(3)** | |
| **(e)** | **N.B.** If **more than two** answers given, subtract 1 from any marks earned for each incorrect extra answer which are in group 7 below but do **not** penalise answers which are in group 8 and then, on ePEN, award as appropriate either: B1B1, B1B0 or B0B0 but NOT B0B1. | B1<br>B1 | 3.5b<br>3.5b |
| | | **(2)** | |
| | | | **(12 marks)** |

| **Notes:** | |
|---|---|
| **(a)** | **N.B.** Mark (a) and (b) together if no labelling. |

| | |
|---|---|
| **M1** | Use one or two equations of motion to form an equation in $R$ only but allow a different letter, with $a = 0.6$ substituted.<br>For each equation used, need all terms and dimensionally correct but condone sign errors. |
| **A1** | Correct unsimplified equation in $R$ or their $R$ |
| **A1*** | Obtain given answer from correct working but condone missing brackets around 600+800 if they are implied by subsequent working.<br>**N.B.** Need to see $R = 500$<br>**N.B.** Allow verification with $R = 500$ used to show that $a = 0.6$, but must state that $R = 500$ at the end to earn this mark. |
| **(b)** | **N.B.** The working for this part may appear in (a). |
| **M1** | Use the equation of motion for the car or trailer to form an equation in $T$<br>need all terms and dimensionally correct but condone sign errors, with $a = 0.6$ substituted. |
| **A1** | Correct unsimplified equation in $T$ only |
| **A1** | Correct only |
| **(c)** | |
| **B1*** | Correct justification of given answer |
| **(d)** | |
| **M1** | Use a complete *suvat* method to find an equation in $d$ only<br>**N.B**. Allow the use of another letter other than $d$, e.g. $s$, for this mark. |
| **A1** | Correct unsimplified equation in $d$ or $s$<br>**N.B.** if they use $s$, allow $0 = 12.5^2 \pm 2 \times \frac{5}{6} \times s$ |
| **A1** | 94 or better<br>**N.B.** if they use $s$ in their equation, they must then state $d =$ or have said that $s = d$ to earn this mark. |
| **(e)** | **N.B. On Epen, these are the only possible marks: B1B1, B1B0 or B0B0** |
| **B1**<br>**B1** | Any two **different** appropriate reasons.<br>Do not accept more than **one** from each of the 6 groups below.<br>Award B1 for any **one** reason which is in any of the 6 groups.<br><br>**Correct answers (not verbatim but equivalent to)**<br>**1.**<br>Resistance to motion of the trailer will be different (when not in the slipstream of the car). or there will be more air or wind resistance.<br>Resistance to motion of the trailer will not be constant/ be exactly 500 N.<br>Wind or air resistance would not be constant.<br>The deceleration won't be constant/ be exactly 5/6 m $s^{-2}$ .<br><br>**2.**<br>The model takes no account of forces acting side to side.<br>The trailer may not continue to move in a straight line. |

| | |
|---|---|
| | **3.**<br>The trailer could be affected by any unevenness of the road e.g. potholes, bumps etc<br>Does not take account of the type of ground.<br>**4.**<br>Not considered the mass of the towbar.<br>**5.**<br>Trailer emergency brake may engage.<br>**6.**<br>After the towbar breaks the trailer will tip and drag on the road.<br>The trailer will be unstable.<br><br>**Incorrect answers which incur a penalty (not verbatim but equivalent to).**<br>**7.**<br>Any answer which mentions the car.<br>The acceleration wouldn't be equal.<br>Not considered the length of the trailer.<br>Road might not be straight and/or horizontal.<br>Mass of the trailer.<br>Does not take friction (between the tyres and the ground) into account.<br>Does not take air resistance into account.<br>Does not take wind resistance into account.<br><br>**Incorrect answers which do NOT incur a penalty (not verbatim but equivalent to).**<br>**8.**<br>Obstacles in the road or cars which the trailer could hit.<br>Does not take account of weather conditions e.g. wind, rain, snow etc<br>The dimensions/shape of the trailer would slow it down.<br>It won't be travelling at a constant speed oe. |

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom