Pearson

# Mark Scheme (Results)

January 2018

Pearson Edexcel
International Advanced Subsidiary Level
In Mechanics M2 (WME02)
Paper 01

edexcel

**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

January 2018
Publications Code WME02_01_1801_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.

# PEARSON EDEXCEL IAL MATHEMATICS

## General Instructions for Marking

1. The total number of marks for the paper is 75

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
   - o.e. – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - $\lfloor$ or d… 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.

5. 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.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

## 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.
- 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

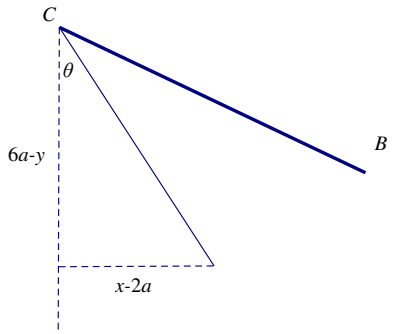
  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

# Jan 2018
# Mechanics WME02
# Mark Scheme

| Q | Scheme | Marks | Notes |
|---|---|---|---|
| **1.** | Impulse- momentum equation | M1 | Must be subtracting velocities (or equivalent). Dimensionally correct. |
| | $4\mathbf{i}+5\mathbf{j}=\frac{1}{2}(\mathbf{v}-(2\mathbf{i}-3\mathbf{j}))$ | A1 | Correct unsimplified equation. |
| | $\mathbf{v}=10\mathbf{i}+7\mathbf{j}$ | A1 | Seen or implied |
| | KE Gain | M1 | Dimensionally correct. Condone ± Must be difference of two KE terms. |
| | $=\frac{1}{2}0.5(10^2+7^2-(2^2+(-3)^2))$ | A1ft | Correct unsimplified expression Follow their **v** . Condone ± |
| | $=34$ J | A1 | CSO |
| | | **(6)** | |
| | | | |
| **2(a)** | Use of $a=\frac{\mathrm{d}v}{\mathrm{d}t}$ | M1 | Usual rules for differentiation. Condone slip in multiplying brackets |
| | $v=3t-2t^2-1,\ a=\frac{\mathrm{d}v}{\mathrm{d}t}=3-4t$ | A1 | |
| | $t=\frac{1}{2},\ a=1\ \left(\mathrm{m\,s^{-2}}\right)$ | A1 | CSO |
| | | **(3)** | |
| | | | |
| **2(b)** | $v=0\Rightarrow t=0.5$ | B1 | Seen or implied |
| | $s=\int 3t-2t^2-1\ \mathrm{d}t$ | M1 | Usual rules for integration |
| | $=\frac{3t^2}{2}-\frac{2t^3}{3}-t(+C)(=F(t))$ | A1ft | Follow their $v$ |
| | Correct strategy for distance | M1 | For their "0.5" in (0,1) Must take account of change in direction |
| | $-[F(t)]_0^{0.5}+[F(t)]_{0.5}^1=F(1)-2F(0.5)+F(0)$ | A1 | Or equivalent, accept ± . For their $F(t)$ |
| | $\left(=\frac{5}{24}+\frac{1}{24}\right)=0.25$ m | A1 | CSO |
| | | | NB Candidates who show no working and use their calculator to integrate must be starting with the correct function and show no errors in order to be able to score any marks. Full marks are available for a correct answer with no error seen. |
| | | **(6)** | |
| | | **[9]** | |
| | | | |
| | | | |
| | | | |
| | | | |

| Q | Scheme | Marks | Notes |
|---|---|---|---|
| **3(a)** | $36a^2(6)$ \| $6a^2(1)$ \| $30a^2(5)$<br>$3a$ \| $\frac{14a}{3}$ \| $\bar{x}$<br>$3a$ \| $5a$ \| $\bar{y}$ | B1 | Mass ratios for a valid combination of shapes |
| | | B1 | Distance from *OD* or equivalent for a valid combination of shapes |
| | | B1 | Distance from *OA* or equivalent for a valid combination of shapes |
| | $6\times3a-1\times\frac{14a}{3}=5\,\bar{x}$<br>or $6\times3a-1\times5a=5\,\bar{y}$ | M1 | Moments equation for a horizontal or vertical axis or a vector equation combining both. For a valid dissection. |
| | $\Rightarrow\ \bar{x}=\frac{8a}{3}$ | A1 | One correct distance |
| | $\bar{y}=\frac{13a}{5}$ | A1 | Both distances correct |
| | | **(6)** | |
| **3(a) alt** | $12a^2$ \| $6a^2$ \| $12a^2$ \| $30a^2$<br>$a$ \| $\frac{10a}{3}$ \| $4a$ \| $\bar{x}$<br>$3a$ \| $4a$ \| $\frac{3a}{2}$ \| $\bar{y}$ | | |
| | | | |
| **3(b)** |  | | |
| | $\theta=\tan^{-1}\left(\frac{\bar{x}-2a}{6a-\bar{y}}\right)$ | M1 | Trig ratio of a relevant angle |
| | $\alpha=\tan^{-1}\left(\frac{4}{3}\right)-\tan^{-1}\left(\frac{\bar{x}-2a}{6a-\bar{y}}\right)$ | DM1 | expression for the required angle for their $\bar{x},\bar{y}$ |
| | $\left(\text{or } \tan^{-1}\left(\frac{6a-\bar{y}}{\bar{x}-2a}\right)-\tan^{-1}\left(\frac{3}{4}\right)\right)$<br>$\left(\text{or } 90-\theta-\tan^{-1}\frac{3}{4}\right)$ | A1ft | Correct unsimplified substituted expression |
| | $\alpha=42^{\circ}$ | A1 | The Q asks for the answer to the nearest degree. |
| | | **(4)** | |
| | | | See over page |

| Q | Scheme | Marks | Notes |
|---|---|---|---|
| **3(b) alt** | Correct method for lengths of all three sides of triangle CBG | M1 | $\left(\sqrt{\frac{2701}{225}}a,\ \sqrt{\frac{2536}{225}}a,\ 5a\right)$ |
| | Correct use of cosine rule | M1 | |
| | $\cos\alpha = \dfrac{25+\frac{2701}{225}-\frac{2536}{225}}{2\times5\times\sqrt{\frac{2701}{225}}}$ | A1ft | Correct unsimplified for their values of the correct distances |
| | $\alpha = 42^{o}$ | A1 | The Q asks for the answer to the nearest degree. |
| | | **(4)** | |
| | | **[10]** | |
| | | | |
| | | | |
| | | | |

| Q | Scheme | Marks | Notes |
|---|---|---|---|
| **4(a)** |  | | NB three variants possible: both to right, both to the left or as diagram |
| | Conservation of momentum | M1 | Dimensionally correct. All terms required. Condone sign errors |
| | $2mu - 3mu = -2mv_P + mv_Q \quad \left(-u = -2v_P + v_Q\right)$ | A1 | Correct unsimplified equation |
| | Impact law | M1 | Must be used the right way round. Condone sign errors. |
| | $4eu = v_P + v_Q$ | A1 | Correct unsimplified equation. Signs consistent with CLM equation |
| | Solve simultaneous equations for $v_P$ or $v_Q$ | DM1 | Dependent on the 2 preceding M marks |
| | $v_P = \frac{u(1+4e)}{3}$ | A1 | One correct (must be positive) or equivalent |
| | $v_Q = \frac{u(8e-1)}{3}$ | A1 | Both correct (must be positive) or equivalent |
| | | **(7)** | |
| | | | |
| **4(b)** | $\frac{u(1+4e)}{3} > 0$ | M1 | Working from a correct inequality for their $v_P$ |
| | Always true because $e \geq 0 \quad \left(\text{or } e > \frac{1}{8}\right)$ | A1 | Correct justification from correct work |
| | | **(2)** | |
| | | | |
| **4(c)** | $e = \frac{3}{4} \Rightarrow v_Q = \frac{5u}{3}$ | B1 | Seen or implied |
| | Speed of $Q$ after collision $= fv_Q$ | M1 | Impact law for collision with the wall |
| | To collide with $P$: $fv_2 > v_1 = \frac{4u}{3}$ | M1 | Correct inequality for second collision |
| | $1 \geq f > \frac{4}{5}$ | A1 | Both limits required |
| | | **(4)** | |
| | | **[13]** | |
| | | | |
| | | | |
| | | | |
| | | | |

| Q | Scheme | Marks | Notes |
|---|---|---|---|
| **5(a)** | Moments about $A$ | M1 | or a complete method to form an equation in $R$ and $W$ |
| | $W \times 8b\cos\theta = R \times 12b$ | A1 | Correct unsimplified equation |
| | $R = \frac{2W}{3}\cos\theta = \frac{2W}{3} \times \frac{12}{13}$ | DM1 | Substitute correctly for trig and solve for $R$<br>Dependent on preceding M1 |
| | $R = \frac{8W}{13}$ | A1 | Allow $R = 0.615W$ |
| | | **(4)** | |
| | | | |
| **5(b)** | Resolve horizontally | M1 | Form one equation in $X$ and/or $Y$ |
| | $(\rightarrow)\ X = R\sin\theta \left( = \frac{40W}{169} \right)$ | A1 | Correct unsimplified equation |
| | Resolve vertically | M1 | Form a second equation in $X$ and/or $Y$ |
| | $(\uparrow)\ Y = W - R\cos\theta \left( = \frac{73W}{169} \right)$ | A1 | Correct unsimplified equation |
| | Parallel to rod: $W\sin\theta = X\cos\theta + Y\sin\theta$ | | |
| | Perpendicular: $R + Y\cos\theta = W\cos\theta + X\sin\theta$ | | |
| | $\tan\alpha = \frac{X}{Y}$ | DM1 | Use their $X$ and $Y$ to find $\tan\alpha$<br>Dependent on M marks for the two equations |
| | $\tan\alpha = \frac{40}{73}$ **Given answer** | A1 | Obtain given answer from correct work |
| | | **(6)** | |
| | | **[10]** | |
| | | | |
| | | | |

| Q | Scheme | Marks | Notes |
|---|---|---|---|
| **6(a)** | $F = \dfrac{1000P}{10}$ | M1 | Use of $P = Fv$ |
| | Equation of motion | M1 | All terms required. Dimensionally correct. Accept separate equations for the car and the trailer. |
| | $F - 300g\sin\alpha - 800g\sin\alpha - 200 - 600 = 1100\times 0.5$ | A1 | Unsimplified equation(s) with at most one error |
| | | A1 | Correct unsimplified equation in $F$ (or $P$) |
| | $P = 21.2$ | A1 | Accept 21. Max. 3 sf |
| | | **(5)** | |
| | | | |
| **6(b)** | Work-energy equation for the trailer | M1 | The Q requires work-energy. Equation for the trailer, with all terms dimensionally correct. Condone sign errors |
| | $200d = \dfrac{1}{2}.300.12^2 - 300dg\sin\alpha$ | A1 | Unsimplified equation with at most one error |
| | | A1 | Correct unsimplified equation |
| | Solve for $d$ | DM1 | Dependent on the previous M1 |
| | $d = 52.7\ (\text{m})$ or $53\ (\text{m})$ | A1 | Max 3 sf |
| | | **(5)** | |
| | | **[10]** | |
| | | | |
| | | | |
| | | | |

| Q | Scheme | Marks | Notes |
|---|---|---|---|
| **7(a)** | Horizontal distance in terms of $U$, $t$ and $\alpha$ | M1 | |
| | $x = Ut\cos\alpha$ | A1 | Correct unsimplified equation |
| | Vertical distance in terms of $U$, $t$ and $\alpha$ | M1 | Condone sign error |
| | $y = Ut\sin\alpha - \frac{1}{2}gt^2$ | A1 | Correct unsimplified equation |
| | $y = U\sin\alpha\frac{x}{U\cos\alpha} - \frac{1}{2}g(\frac{x}{U\cos\alpha})^2$ | DM1 | Substitute for $t$<br>Dependent on the first 2 M marks |
| | $y = x\tan\alpha - \frac{gx^2\sec^2\alpha}{2U^2}$ | DM1 | Simplify the trig. and use Pythagoras<br>Dependent on the first 2 M marks |
| | $y = x\tan\alpha - \frac{gx^2(1+\tan^2\alpha)}{2U^2}$ given answer | A1 | Obtain **given answer** from correct working |
| | | **(7)** | |
| | | | |
| **(b)** | $(\rightarrow)\ v_H = U$ | B1 | Horizontal component in $U$, $g$, $T$ |
| | $(\downarrow)\ v_V = gT$ | B1 | Vertical component in $U$, $g$, $T$. Accept $\pm$ |
| | Use of Pythagoras | M1 | |
| | $v = \sqrt{U^2 + g^2T^2}$ | A1 | Or equivalent. Allow $t$ for $T$ |
| | | **(4)** | |
| **(b) alt** | $-h = d\tan 0 - \frac{gd^2}{2U^2}(1+\tan^2 0)$ | B1 | $\left(h = \frac{gd^2}{2U^2}\right)$ |
| | $d = UT\ \left(\Rightarrow h = \frac{gT^2}{2}\right)$ | B1 | |
| | $\frac{1}{2}mv^2 - \frac{1}{2}mU^2 = mgh$ | M1 | Energy equation |
| | $v^2 = U^2 + 2gh = U^2 + g^2T^2$ , $v = \sqrt{U^2 + g^2T^2}$ | A1 | |
| | | **(4)** | |
| | | | |
| **(c)** | $d = UT$ | B1 | Horizontal distance |
| | $-h = d\tan\alpha - \frac{gd^2(1+\tan^2\alpha)}{2U^2}$ | M1 | Substitute for $x$ and $y$ in given equation.<br>Condone sign error |
| | $h = \frac{1}{2}gT^2$ | B1 | Vertical distance |
| | $-\frac{1}{2}gT^2 = d\tan\alpha - \frac{g(UT)^2(1+\tan^2\alpha)}{2U^2}$ | M1 | Substitute to eliminate $U$ from the equation |
| | $0 = d\tan\alpha - \frac{gT^2}{2}\tan^2\alpha$ | A1 | Correct equation in $T$ and $d$ |
| | $d = \frac{1}{2}gT^2\tan\alpha$ **given answer** | A1 | Obtain given answer from correct working |
| | | **(6)** | |
| | | **[17]** | |
| | | | |

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