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Mark Scheme (Results)

October 2022

Pearson Edexcel International Advanced Level In Mechanics M1 (WME01) Paper 01

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- 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.

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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
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

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3. General 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

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.

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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)

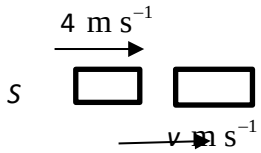
  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side

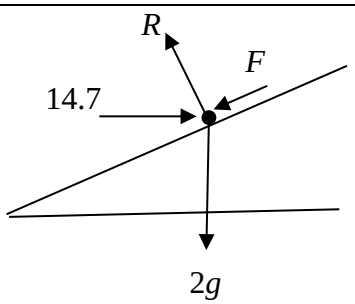
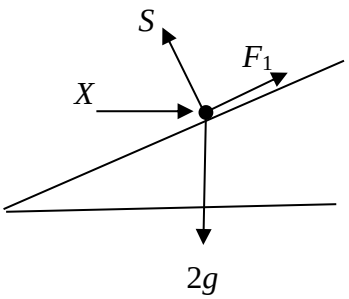
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Question Number	Scheme	Marks
1.		
1(a)	$20000\times 4 = 50000v$ $v = 1.6(\text{m s}^{-1})$ **OR** $20(-v-(-4)) = 30(v-0)$	M1 A1
		(2)
1(b)	$\pm 20000(1.6-4)$ **OR** $\pm 30000\times 1.6$	M1A1**ft**
	48000 N s or 48 kN s	A1
	.	(3)
		(5)
	Notes for question 1	
1(a)	M1 for a CLM equation, condone sign errors and extra *g*'s and any equivalent equation (e.g. 2 x 4 = 5*v*, 20 x 4 = 50*v*, 200 x 4 = 500*v*,… etc) OR : for equating impulses	
	A1 oe Units **not** needed **but must be positive**.	
1(b)	M1 impulse-momentum equation, dimensionally correct, correct no. of terms, condone sign errors but must be attempting a difference of momenta (allow 20 or 30 for the mass, M0 if *g* included or mass omitted)	
	A1**ft** a correct equation, follow through on their *v* (allow 20 or 30 for the mass) **N.B**. If using *S* to find the impulse, 4 and their *v* must have opposite signs when awarding the A1ft.	
	A1 cao **units needed** (allow kg m s^{-1}) and must be positive.	

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Question Number	Scheme	Marks
2(a)	M(D), $\frac{3a}{5}Xg = \frac{2a}{5}Mg$ Other possible equations: $(\uparrow) T_D = Mg + Xg$ M(A), $Mga + Xg\,2a = T_D\frac{7a}{5}$ M(B), $Mga = T_D\frac{3a}{5}$ T_D would then need to be eliminated M(C), $Mg\frac{3a}{5} + Xg\frac{8a}{5} = T_D a$ M(G), $Xga = T_D\frac{2a}{5}$	M1A1
	$X = \frac{2M}{3}$, 0.67 M or better	A1 (3)
2(b)	M(D), $T_C a + \frac{1}{2}Mg\frac{3a}{5} = \frac{2a}{5}Mg$ Other possible equations: $(\uparrow) T_C + T_D = Mg + \frac{1}{2}Mg$ M(A), $Mga + \frac{1}{2}Mg\,2a = T_C\frac{2a}{5} + T_D\frac{7a}{5}$ M(B), $Mga = T_C\frac{8a}{5} + T_D\frac{3a}{5}$ T_D would need eliminating M(C), $Mg\frac{3a}{5} + \frac{1}{2}Mg\frac{8a}{5} = T_D a$ M(G), $T_C\frac{3a}{5} + \frac{1}{2}Mga = T_D\frac{2a}{5}$	M1A1
	$T_C = \frac{1}{10}Mg$ oe	A1 (3)
		(6)
	Notes for question 2	
2(a)	M1 For an equation (or inequality,,,) in X , M and *a only* (allow consistent missing a's) with correct no. of terms. Allow if one g is missing. **N.B.** M0 if Tc appears and never becomes zero	
	A1 Correct equation or inequality	
	A1 cao	
2(b)	M1 For an equation in Tc , M , g and *a only* (allow consistent missing a's or if g('s) missing) with correct no. of terms M0 if they assume that $T_C = T_D$ or if they assume their X value from (a).	
	A1 Correct equation	
	A1 cao	

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Question Number	Scheme	Marks
3(a)		
	$(\square),14.7\cos\alpha = 2g\sin\alpha + F$ (could be $-F$) **OR:** $(\rightarrow),14.7 + F\cos\alpha = R\sin\alpha$ $(\uparrow), R\cos\alpha + F\sin\alpha = 2g$ **AND** eliminate R to give an equation in F only. <u>Verificaton methods</u> $14.7\cos\alpha = (11.76) = 2g\sin\alpha$ (i.e. verification that $X = 14.7 \Rightarrow F = 0$) **OR**: $X\cos\alpha = 2g\sin\alpha \Rightarrow X = 14.7$ (i.e. verification that $F = 0 \Rightarrow X = 14.7$)	M1 A1
	so $F = 0$* oe	A1*
		(3)
		
3(b)	$F_1 = 0.5S$	B1
	Two equations taken from: $(\square), X\cos\alpha + F_1 = 2g\sin\alpha$ $(\square), S = X\sin\alpha + 2g\cos\alpha$ $(\rightarrow), X + F_1\cos\alpha = S\sin\alpha$ $(\uparrow), S\cos\alpha + F_1\sin\alpha = 2g$	M1A2 M1A2

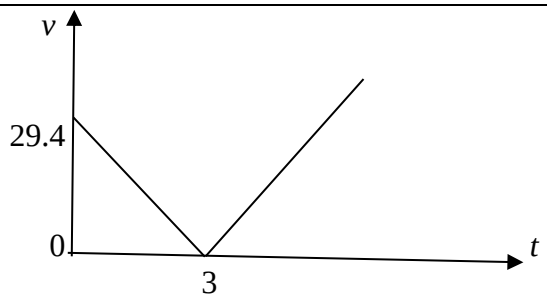
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	N.B. M0 for both equations if they put $X = 14.7$ anywhere	
	$X = 4g/11$, 3.6 or 3.56 or 3.57	A1
	N.B. Enter marks for the equations on ePen in the order in which they appear above.	
		(8)
		(11)
	Notes for question 3	
3(a)	M1 Equation in F only, correct no of terms, condone sign errors and sin/cos confusion (M0 if they use $F = 0.5R$) **N.B**. Allow the equation without F Allow use of m instead of 2 for the Mmark	
	A1 Correct equation	
	A1* cao Must state a conclusion or , if verifying, must state clearly $X = 14.7 \Rightarrow F = 0$ **OR** $F = 0 \Rightarrow X = 14.7$	
3(b)	B1 $F_1 = 0.5S$ *seen* e.g. on a diagram (even if wrong direction)	
	M1 A resolution, correct no of terms, condone sign errors and sin/cos confusion Allow use of m instead of 2 for the A mark	
	A2 Correct equation, -1 each error	
	M1 A resolution, correct no of terms, condone sign errors and sin/cos confusion Allow use of m instead of 2 for the A mark	
	A2 Correct equation, -1 each error	
	A1 cao	

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Question Number	Scheme	Marks
4(a)	$3616 - 250g - 565 - 226 = 250a$	M1 A1
	$a = 1.5$ (m s^{-2})	A1
		(3)
4(b)	$565 - mg = m \times 1.5$	M1A1**ft**
	m = 50 (kg)	A1
		(3)
		(6)
	Notes for question 4	
4(a)	M1 Equation in a **only**, correct no. of terms, condone sign errors	
	A1 Correct equation	
	A1 oe	
4(b)	M1 Equation in m (mass of A) **only**, correct terms, condone sign errors	
	A1**ft** Correct equation ft on their a	
	A1 cao	

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Question Number	Scheme	Marks
5(a)	$0 = 14.7^2 - 2gs$	M1A1
	22 or 22.1 (m)	A1
		(3)
5(b)	$19.6 = 29.4t + \frac{1}{2}gt^2$ **N.B.** $19.6 = 29.4t - \frac{1}{2}gt^2$ is M0A0 $-19.6 = 29.4t + \frac{1}{2}gt^2$ is M0A0 $-19.6 = 29.4t - \frac{1}{2}gt^2$ is M0A0 unless they go on to subtract 6 from the positive root	M1A1
	t = 0.61 or 0.606 (s)	A1
		(3)
5(c)		B1 shape B1 29.4 B1 3
		(3)
		(9)
	Notes for question 5	
5(a)	M1 Complete method to find distance **UP** **N.B.** They may find time UP (1.5s) **AND** use it to find distance UP **OR**: (Distance from *A* to top – Distance from '14.7' to top) = (44.1 – 33.075)	
	A1 Correct equation(s) used	
	A1 cao	
5(b)	M1 Complete method to find required time **N.B.** They may find the speed as it hits the ground ($g\sqrt{13} = 35.334...$) AND use it to find the time.	
	A1 Correct equation(s) used	
	A1 cao **N.B.** If they add to or subtract from 0.606, it's M0 for an incorrect method.	
5(c)	B1 V shape with *v* coord of end pt > 29.4 and each half roughly equally inclined to the *t*-axis. B0 if a vertical line is included at the end.	
	B1 29.4 independent	
	B1 3 independent	

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Question Number	Scheme	Marks
6(a)	$(-3\mathbf{i}+2\mathbf{j})+(p\mathbf{i}+q\mathbf{j})=(-3+p)\mathbf{i}+(2+q)\mathbf{j}$	M1
	$\frac{(-3+p)}{(2+q)}=\frac{1}{-2}$	M1A1
	$2p+q-4=0$ * Allow $0=2p+q-4$ but nothing else	A1*
		(4)
6(b)	p = 5 => q = -6 => Resultant force = $(2\mathbf{i}-4\mathbf{j})$	B1
	$(2\mathbf{i}-4\mathbf{j})$ = 0.5**a**	M1
	v = $(4\mathbf{i}-8\mathbf{j})\times 4$	M1
	Speed = $\sqrt{16^2+(-32)^2}$ = $\sqrt{1280}=16\sqrt{5}$ = 36 (m s^{-1}) or better	M1A1
		(5)
		(9)
	Notes for question 6	
6(a)	M1 For adding *and* collecting **i**'s and **j**'s. **N.B**. Could be implied by p = 4 *and* q = -4	
	M1 Using ratios oe to set up an equation in p and q only, allow the ratio the wrong way round. M0 if they write down: $-3+p=1$ and $2+q=-2$ and NEVER use ratios, but ignore these equations if they go on to use ratios	
	A1 Correct equation	
	A1* Correct answer correctly obtained	
6(b)	B1 Correct resultant force seen	
	M1 Use of **F** = *m***a** OR *F* = *ma* where **F** (*F*) is their *resultan*t (must have attempted to add the two forces) (M0 if they include *g*)	
	M1 Use of **v** = **a***t* OR *v* = *at* with *t* = 4 where **a** or *a* is **their** acceleration. (M0 if **u** or *u* is non-zero)	
	M1 Use of Pythagoras to find magnitude of **v** OR **a** OR **F**, including square root	
	N.B. The above 3 steps may appear in any order but must be entered on ePen in the order as above.	
	A1 Any equivalent surd or correct to at least 2 SF	

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Question Number	Scheme	Marks
7(a)	$F = \mu mg$	B1
	For P: $mg - kmg = ma$ Allow $mg - T = ma$	M1A1
	For Q: $kmg - F = ma$ Allow $T - F = ma$	M1A1
	Either of these may be replaced by : $mg - F = 2ma$ (whole system)	
	Produce an equation in k and μ only using $T = kmg$	M1
	$k = \frac{1}{2}(1+\mu)$	A1
		(7)
7(b)	Attempt to find the acceleration. [Note that some possible correct forms are: $a = \frac{1}{2}g(1-\mu)$ or $g(1-k)$ or $g(k-\mu)$]	M1
	$d = \frac{1}{2} \times \frac{1}{2} g(1-\mu)t^2$	M1A1
	$t = \sqrt{\frac{4d}{g(1-\mu)}}$	A1
		(4)
7(c)	P or Q (or the system) would not move	B1
	Accept any of $T = mg$, $T > mg$, $T \geq mg$, $a = 0$, $a < 0$, $a \leq 0$ $F = T$, $F > T$, $F \geq T$, $F > mg$. Allow F replaced by μR **N.B**. Forces referred to must be clearly defined so e.g. use of vague terms like 'forward force' , 'opposite force', 'force to the left or right' is B0.	**D**B1
		(2)
		(13)

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	Notes for question 7	
7(a)	B1 for $F = \mu mg$ seen e.g. on a diagram	
	M1 Equation of motion for P with correct no. of terms, condone sign errors	
	A1 Correct equation (allow $-a$)	
	M1 Equation of motion for Q with correct no. of terms, condone sign errors	
	A1 Correct equation (allow $-a$) **N.B**. ($-a$) must be used in both equations	
	M1 for producing **an equation** in k and μ only	
	A1 oe Must appear in (a)	
7(b)	M1 Attempt to find the acceleration in terms of g and μ or g and k or g, k and μ	
	M1 Complete method to find an equation in d, g, t and μ only, condone a sign error.	
	A1 Correct equation in d, g, t and μ only	
	A1 Any equivalent form	
7(c)	B1 Correct statement. B0 if incorrect extras.	
	DB1 Correct reason	

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Question Number	Scheme	Marks
	Allow column vectors throughout	
8(a)	$\sqrt{3^2+12^2}$	M1
	$\sqrt{153}$, $3\sqrt{17}$, 12 or better (km h^{-1})	A1
		(2)
8(b)	$(-9\mathbf{i}+6\mathbf{j})+t(3\mathbf{i}+12\mathbf{j})$	M1 A1
	$(16\mathbf{i}+6\mathbf{j})+t(p\mathbf{i}+q\mathbf{j})$	A1
	$\overrightarrow{AB}=\mathbf{b}-\mathbf{a}=(16\mathbf{i}+6\mathbf{j})+t(p\mathbf{i}+q\mathbf{j})-\left((-9\mathbf{i}+6\mathbf{j})+t(3\mathbf{i}+12\mathbf{j})\right)$	M1 A1
	$=\left[25+t(p-3)\right]\mathbf{i}+t(q-12)\mathbf{j}\right]$	
	Compare with: $\left[(25-12t)\mathbf{i}-9t\mathbf{j}\right]$ or e.g. use $\mathbf{b}=\mathbf{AB}+\mathbf{a}$ to obtain an equation in p only and an equation in q only. May be implied by correct answers only. $(-12=p-3$ and $-9=q-12)$ **N.B.** This mark may not be available if they go wrong and the t's don't cancel.	M1
	$p=-9$, $q=3$	A1
		(7)
8(c)	$(25-12t)^2+(-9t)^2=15^2$ $\quad(225t^2-600t+400=0)$	M1A1
	$t=\dfrac{4}{3}$	A1
	$\pm(9\mathbf{i}-12\mathbf{j})$ Note that this a method mark.	**DM**1
	$\tan\theta=\dfrac{9}{12}$	M1
	$\theta=37^o$	A1
	Bearing is 323^o to nearest degree	A1
		(7)
		(16)

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	Notes for question 8	
8(a)	M1 Use of Pythagoras with square root	
	A1 cao	
8(b)	M1 Correct structure for either	
	A1 cao	
	A1 cao	
	M1 Allow **a** − **b**	
	A1 for a correct **unsimplified** expression for either **b** – **a** or **a** – **b**	
	M1 for an equation in *p* only and an equation in *q* only	
	A1 cao	
8(c)	M1 Use of Pythagoras to give an equation in *t* only Allow with a square root.	
	A1 Correct unsimplified quadratic equation	
	A1 $t = 1.3$ or better	
	DM1 Use of their *t* to find $\overrightarrow{AB}$ or $\overrightarrow{BA}$, dependent on previous M. May be implied. Allow if they use one of their two incorrect *t* values.	
	M1 For an equation in a relevant angle for their **AB.** Could be implied by a relevant angle seen on a diagram which could need checking with a calculator	
	A1 Correct relevant angle e.g $37^o, 53^o, 127^o, etc$ or better	
	A1 cao	

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