Mark Scheme (Results)

October 2018

Pearson Edexcel International Advanced Level in Mechanics M1 (WME01/01)

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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.

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
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.

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 $\surd$ 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.

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.

  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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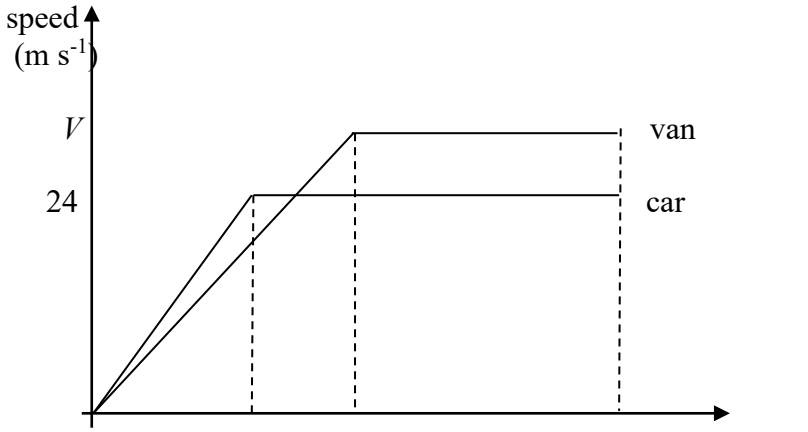
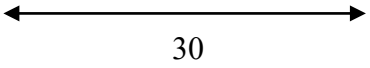
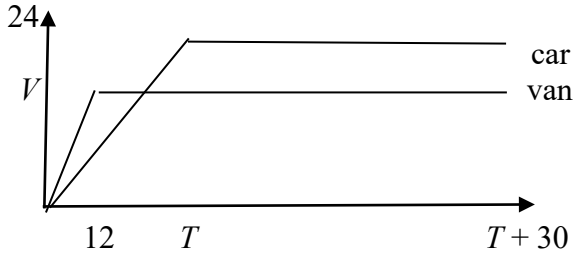
WME01 (M1)
FINAL

Question Number	Scheme	Marks
1(a)	$0.8\times4-2\times2=2v-0.8\times2.5$	M1A1
	$v=0.6$ m s^{-1}	A1 (3)
(b)	$I=0.8(4+2.5)=5.2$, Ns or kg m s^{-1}	M1A1,B1 (3)
	OR: $I=2(0.6+2)=5.2$, Ns or kg m s^{-1}	M1A1,B1 **[6]**
	Notes for qu 1	
1a	M1 for CLM, correct no. of terms, dim correct, condone extra g's throughout and sign errors, in one unknown, with correct pairings of mass and velocity. N.B. Apply <u>same</u> criteria to an equation that has been found by eliminating the impulse from two imp-mom equations.	
	First A1 for a correct equation (condone extra g's)	
	Second A1 for 0.6 (Must be positive)	
1b	M1 for Impulse – Momentum equation for either particle, correct no. of terms, with correct velocities, condone sign errors N.B. Mark the actual equation not the formula (some candidates use $I=m(v+u)$ when the direction has been reversed)	
	M0 if g included on momentum terms	
	A1 for 5.2 (Must be positive)	
	B1 for Ns or kg m s^{-1} **N.B.** M0A0B1 is possible	

Question Number	Scheme	Marks
2(a)	**N.B.** Consistent use of extra *g*'s in **two** equations can score the A marks for the equations and could score full marks for part (a). **N.B.** If they assume that the rod is uniform, can only score marks for a vertical resolution. $\text{R}(\uparrow)$: $0.5R_C + R_C = 60 + 12$ (N.B. $R_A = \frac{1}{2}R_C$)	M1A1
	Possible moments equations: $\text{M}(A)$: $60x + (12\times 5) = R_C \times 3$ $\text{M}(B)$: $(2\times R_C) + \left(\frac{1}{2}R_C \times 5\right) = 60(5-x)$ $\text{M}(C)$: $(\frac{1}{2}R_C \times 3) + (12\times 2) = 60(3-x)$ $\text{M}(G)$: $12(5-x) + \frac{1}{2}R_C x = R_C(3-x)$	M1A1
	Eliminate R_C and solve for x (AG) $x = 1.4$ m	**DM1** A1 (6)
(b)	(i) the weight of the parcel acts at B (ii) the plank remains straight (or equivalent statements)	B1 B1 (2) **[8]**
	Notes for qu 2	
	N.B. If R and $\frac{1}{2}R$ are reversed, max score is M1A1 (resolution) M1A0 (moments)	
2a	First M1 for first equation, correct no. of terms, dim correct, condone sign errors and allow R and S at this stage and for moments equations allow a different length variable	
	First A1 for a correct resolution in one unknown or moments equation in two unknowns	
	Second M1 for second equation, correct no. of terms, dim correct, condone sign errors and allow R and S at this stage and for moments equations allow a different length variable	
	Second A1 for a correct resolution in one unknown or moments equation in two unknowns	
	Third DM1, dependent on both previous M marks, for eliminating and solving for AG	
	Third A1 for 1.4 (m) oe	
2b (i)	First B1 e.g. mass is concentrated **at *B*** B0 if incorrect extras	
(ii)	Second B1 e.g. the plank doesn't buckle or bend B0 if incorrect extras	

Question Number	Scheme	Marks
3	**EITHER:** $h=-19.6(t+3)+\frac{1}{2}g(t+3)^2$ and $h=\frac{1}{2}gt^2$	M1A1A1
	OR : $h=-19.6T+\frac{1}{2}gT^2$ and $h=\frac{1}{2}g\left(T-3\right)^2$	M1A1A1
	$-19.6T+\frac{1}{2}gT^2=\frac{1}{2}g\left(T-3\right)^2$ **OR** $-19.6(t+3)+\frac{1}{2}g(t+3)^2=\frac{1}{2}gt^2$	M1
(i)	$T=4.5$	A1
(ii)	$h=\frac{1}{2}\times 9.8\times\left(T-3\right)^2$ oe	M1
	$=11$ or 11.0	A1 **[7]**
	Notes for qu 3	
3	First M1 for use of $s=ut+\frac{1}{2}at^2$ (or any other complete method) to produce an equation in *h* and *T only* or *h* and *t only* for stone 1 or 2, correct no. of terms but condone sign errors	
	First A1 for a correct equation for **stone 1** (*g* does not need to be substituted but if it is , it must be 9.8)	
	Second A1 for a correct equation for **stone 2** **N.B**. Both A marks can be earned if they use *s* (instead of *h* or -*h*) in one of the two equations and then use *s* consistently in the other equation. **N.B.** When *h* and *T* are used in any equation, they must be used correctly (including sign of *h*) to obtain A marks	
(i)	Second M1 for eliminating *h*	
	Third A1 for *T* = 4.5	
(ii)	Third M1 for using their *T* or *t* value in one of their equations to obtain an *h* value	
	Fourth A1 for *h* = 11 or 11.0	

Question Number	Scheme	Marks
4.	$\sin\theta = \frac{3}{5}$ or $\cos\theta = \frac{4}{5}$ or $\tan\theta = \frac{3}{4}$ oe (may use the angle the string makes with the horizontal, the complementary angle) seen or implied by use of a trig function of e.g. 37° or 53° anywhere. **N.B.** If they assume angles are 45° can score max B0M1A0A1M0A0A0	B1
	Any *two* of the following equations: R$(\rightarrow)$: $F\cos\theta = 16\sin\theta$ oe e.g. $F = 16\tan\theta$ (from triangle of forces) R($\nearrow$): $F = mg\sin\theta$ R$(\uparrow)$: $mg = 16\cos\theta + F\sin\theta$ R($\nwarrow$): $16 = mg\cos\theta$ $(mg)^2 = F^2 + 16^2$ (Pythagoras from triangle of forces) **N.B**. In all of these equations, θ is what they *think* the angle that the string makes with the vertical is.	M1A1 (1st equation) M1A1 (2nd equation)
(i)	$F = 12$ (A0 if 12 obtained from rounding an inaccurate answer and A0 for 12.0) **N.B. If $F = 12$ is given as answer, without any evidence of rounding, give BOD and award A1.**	A1
(ii)	$m = 2.04$ or 2.0 (A0 for 2)	A1
		[7]
	Notes for qu 4	
	B1 for any correct trig ratio seen	
	First M1 for 1st equation seen with usual rules	
	First A1 for a correct equation	
	Second A1 is now M1 for 2nd equation seen with usual rules	
	Second M1 is now A1 for a correct equation	
	Third A1 for 12	
	Fourth A1 for 2.04 or 2.0 (A0 for 2)	

Question Number	Scheme	Marks
5(a)	 **OR** 	B1 shape of either B1 shape of second (must cross first and end at the same t value) B1 V,24,12, T, T+30 oe with delineator B0 if vertical solid lines (3)
	N.B. 	**This graph can score all 3 marks.**
(b)	$\frac{1}{2}(T+30+30)\times 24=816$ **OR** $\frac{1}{2}\times T\times 24+30\times 24=816$ $T=8$ (s)	M1A1 A1 (3)
(c)	$\frac{1}{2}\big((T+30)+(T+18)\big)V=816$ **OR** $\frac{1}{2}\times 12V+V(18+T)=816$ $V=25.5$	M1A1 **ft** A1 (3) **[9]**
ALT	(b) Dist travelled while accelerating $=816-720=96$ m $s=\frac{u+v}{2}t \Rightarrow\left(\frac{0+24}{2}\right)T=96$ M1A1 $T=8$ (s) A1	

Question Number	Scheme	Marks
	(c) Dist travelled by the van $= \frac{1}{2} \times 12V + (18+T) \times V = 816$ M1A1**ft** $V = 25.5$ A1	
	Notes for qu 5	
5a	First B1 for shape of graph	
	Second B1 for shape of graph, crossing first graph	
	Third B1 for V, 12, 24, T and T+30 placed correctly oe e.g. with delineators. Allow their T and (their T + 30) where they find T in (b) first.	
5b	M1 for equation in T or t (= T + 30) *only* , using 816 distance travelled by CAR, *with correct structure* i.e. a trapezium or (triangle + rectangle)	
	First A1 for a correct equation	
	Second A1 for 8 (s)	
5c	M1 for equation in V *only* , using 816 distance travelled by VAN , *with correct structure* i.e. a trapezium or (triangle + rectangle) **N.B.** M0 if they assume the TOTAL time is 30 (or 42) when setting up the equation.	
	First A1 **ft** on their T value , for a correct equation	
	Second A1 for V = 25.5	

Question Number	Scheme	Marks
6(a)	Speed $= \sqrt{4^2+5^2} = \sqrt{41}$ or 6.4031...m s^{-1} (Accept 6.4 or better)	M1A1 (2)
(b)	$(\mathbf{r} =)\left(3\mathbf{i}-2\mathbf{j}\right)+t\left(\mathbf{4i}+5\mathbf{j}\right)$.	M1A1 (2)
(c)	$\mathbf{j}$ comp $=6$	
	$5T-2=6$	M1
	$T=\frac{8}{5}\ \left(=1.6\right)$	A1 (2)
(d)	$t=1.6\ \Rightarrow\ (\mathbf{r} =)(3+(4\times1.6))\mathbf{i}\ \ \left(+6\mathbf{j}\right)$	M1A1**ft**
	boy travels $9.4-1=8.4$ m (allow 8.4**i)**	A1
	$\frac{8.4}{1.6}$ or $\frac{8.4\mathbf{i}}{1.6}$ $v = 5.25$	**DM**1 A1 (5) **[11]**

	Notes for qu 6	
6a	M1 for attempt to find magnitude of velocity	
	A1 6.4 or better	
6b	M1 for attempt at pv with correct structure i.e. $\mathbf{r}_0 + t\mathbf{v}$	
	A1 for a correct expression seen (ie use isw)	
6c	M1 for equating **j** cpt of their **r** to 6 (Must be of form: $a+bT=6$ oe)	
	A1 for 1.6 oe	
6d	First M1 for substituting their answer for (c), their T, into **i** cpt of their answer for (b) oe	
	First A1 **ft ,** with or without **i**	
	Second A1 for 8.4 or 8.4**i** cao	
	Second DM1, dependent on first M1, for dividing their distance or vector (c**i)** by their T (> 0) value to find the value of v. (9.4/T oe is DM0)	
	Third A1 for 5.25 cao	

Question Number	Scheme	Marks
7(a)	$2560\times0.4=2100-640-R$	M1A1
	$R=436$ * GIVEN ANSWER	A1 * (3)
(b)	Truck: $1600\times0.4=2100-640-T$ **OR** car: $960\times0.4=T-436$	M1A1
	$T=820$ N	A1 (3)
(c)	$2560a'=2100-640-436+1600g\sin\alpha+960g\sin\alpha$ (omission of g is one error)	M1A1A1
	$a'=1.05$ or 1.1 m s^{-2}	A1 (4) **[10]**
	Notes for qu 7	
	Use the *mass* which is being used, in $F=ma$, to decide which part of the system an equation applies to.	
7a	M1 for an equation of motion, dim correct with correct no.of terms, condone sign errors, *in R only*	
	First A1 for a correct equation	
	Second A1 for $R = 436$ GIVEN ANSWER **N.B**. They may do (b) first, using the Truck equation to find $T = 820$, and then use Car equation here to show that $R = 436$	
7b	M1 for an equation of motion, dim correct with correct no.of terms, condone sign errors, for either truck or car, in T only. (Equation could appear in (a) but must be being used in (b))	
	First A1 for a correct equation	
	Second A1 for $T = 820$ (N)	
7c	M1 for an equation of motion *in a' only*, dim correct with correct no.of terms, condone sign errors and missing g's,	
	First and second A1 for a correct equation, -1 each error (Omission of g is one error) If both weight cpts are negative, treat as one error.	
	Third A1 for 1.05 or 1.1 (m s^{-2}) **N.B.** Note that $T = 820$ again but if they just assume that $T = 820$, M0	

Question Number	Scheme	Marks
8(a)	R$(\perp$ plane$)$: $R = 0.5g\cos 30^\circ + 5\sin 30°$	M1A1A1
	$R = 6.743... = 6.7$ or 6.74 N	A1 (4)
(b)	R$(\|\|$ plane$)$: $F = 5\cos 30° - 0.5g\sin 30°$ $(= 1.880...)$	M1A1A1
	$\mu = \frac{F}{R} = \frac{1.880}{6.743}$, $= 0.27880... = 0.28$ or 0.279	M1A1 (5)
(c)	NL2: $0.5g\sin 30° - F' = 0.5a$	M1A1
	R$(\perp$ plane$)$: $R' = 0.5g\cos 30^\circ$ $(= 4.2435...)$	M1A1
	Use of $F' = \mu R' = 0.2787... \times R'$ $(= 1.18345...)$ and solve for a	**DM**1
	$a = 2.53...$ m s^{-2}	A1
	$v^2 = 2as = 2 \times 2.533 \times 3$	M1
	$v = 3.9$ or 3.90 ms^{-1}	A1 (8) **[17]**
	Notes for qu 8	
8a	M1 for resolution perp to the plane, with usual rules	
	First and second A1 for a correct equation, -1 each error	
	Third A1 for 6.7 or 6.74 (N) must be positive	
8b	First M1 for resolution parallel to the plane, with usual rules	
	First and second A1 for a correct equation, -1 each error	
	Second M1 for *use* of $\mu = \frac{F}{R}$	
	Third A1 for 0.28 or 0.279	
8c	**SC: If 5N force is not removed, can score max:** **M1A0M1A0DM1A0M0A0** with usual rules applying for M marks assuming that 5N force still acting.	
	First M1 for equation of motion parallel to plane, with usual rules	
	First A1 for a correct equation (F' does not need to be substituted and allow if they use the value of F from part (b))	
	Second M1 for resolution perp to the plane, with usual rules	
	Second A1 for a correct equation	
	Third DM1, dependent on both previous M marks, for use of $F' = \mu R'$ and	

Question Number	Scheme	Marks
	solving for a	
	Third A1 for $a = 2.53$ or better, if they get v wrong, but if they get $v = 3.9$ then allow $a = 2.5$ or 2.54	
	Fourth M1 (independent but must have used an equation of motion to find a) for complete method to find v using their a M0 if particle is decelerating i.e if their a is negative down the plane.	
	Fourth A1 for $v = 3.9$ or $3.90\ \text{ms}^{-1}$	