Mark Scheme (Results)

January 2017

Pearson Edexcel International A Levels in Mechanics 1(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)

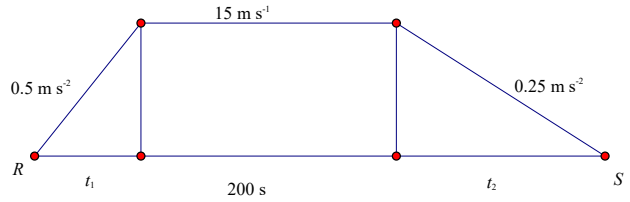
  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

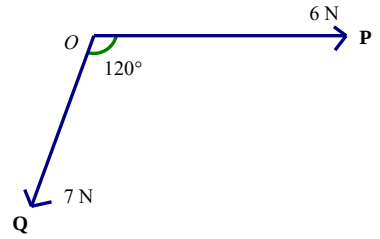
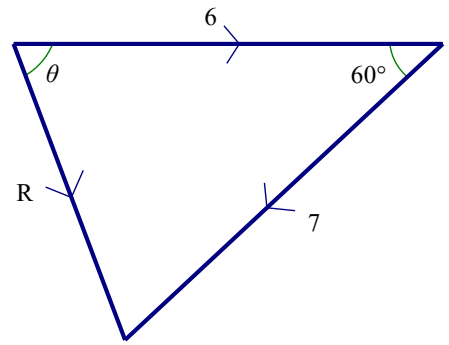
  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

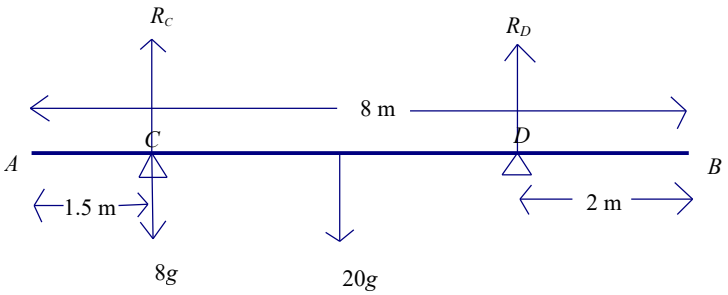
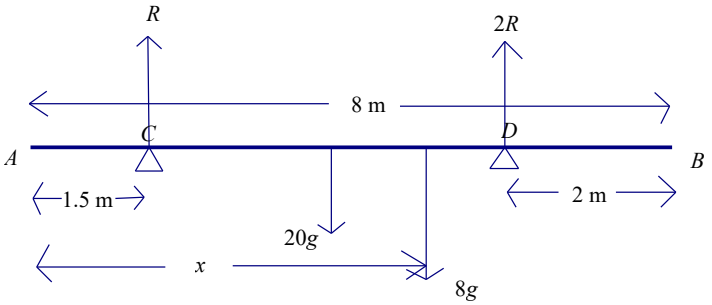
  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1a		
	Use of $v = u + at$ to find t_1 or t_2	M1
	$t_1 = 15 \div 0.5 = 30\,(\text{s})$ **OR** $t_2 = 15 \div 0.25 = 60$	A1
	Total time $= 30 + 200 + 60 = 290\,(\text{s})$	A1 **cso**
		(3)
1b	Use area/ *suvat* to find distance: $\text{distance} = \frac{1}{2} \times 30 \times 15 + 200 \times 15 + \frac{1}{2} \times 60 \times 15$ Follow their t_1 & t_2	M1A2 **ft**
	$= 3675\,(\text{m})$ (3.675 km)	A1
		(4)
1c	$\text{Ave. speed} = \frac{\text{their(b)}}{\text{their(a)}}$	M1
	$= \frac{3675}{290}$ oe (m s^{-1}) (12.6724..)	A1
		(2)
		[9]
	Notes	
1a	M1 for use of $v = u + at$ or gradient or any other complete method to find a value for t_1 or t_2 (condone sign errors)	
	First A1 for either 30 or 60 (A0 if negative)	
	Second A1 for 290 with no errors seen	
1b	M1 for a complete method to find distance (must have a ½) either by using trapezium rule or by using 2 triangles and a rectangle	
	A2 **ft** on their t_1 & t_2 (-1 each error)	
	A1 for 3675 (m) or 3.675 km	
1c	M1 for $= \frac{\text{their(b)}}{\text{their(a)}}$	
	A1 for 13 or better	

Question Number	Scheme	Marks
	Accept column vectors throughout	
2a	Use of $\mathbf{F} = m\mathbf{a}$: $2\mathbf{i} + 3\mathbf{j} = 0.5\mathbf{a}$	M1
	$\mathbf{a} = 4\mathbf{i} + 6\mathbf{j}$ (m s^{-2})	A1
		(2)
2b	Use of $\mathbf{v} = \mathbf{u} + 3\mathbf{a}$ with their $\mathbf{a}$	M1
	$=16\mathbf{i}+18\mathbf{j}$	A1
	Use of Pythagoras: speed $=\sqrt{16^2+18^2}$	M1
	$=\sqrt{580}$ or 24 (m s^{-1}) or better	A1
		(4)
2c	In component form: $\mathbf{v} = 4\mathbf{i} + t(4\mathbf{i} + 6\mathbf{j})$	M1
	$4 + 4T = 2 \times 6T$	M1
	$T = \frac{1}{2}$	A1
		(3)
		[9]
	Notes	
2a	M1 for use for $\mathbf{F} = m\mathbf{a}$:	
	A1 for $4\mathbf{i} + 6\mathbf{j}$ (m s^{-2}) isw if magnitude found.	
2b	First M1 for $\mathbf{v} = 4\mathbf{i} + 3(4\mathbf{i} + 6\mathbf{j})$ with their $\mathbf{a}$ (but M0 if they use 2**i** + 3**j** (the force) instead of **a**)	
	First A1 for $16\mathbf{i}+18\mathbf{j}$ seen or implied	
	Second M1 for finding magnitude of their **v**	
	Second A1 for 24 or better (24.0831…) or √580	
2c	First M1 for $\mathbf{v} = 4\mathbf{i} + t(4\mathbf{i} + 6\mathbf{j})$ with their $\mathbf{a}$ (but M0 if they use 2**i** + 3**j** (the force) instead of **a**)	
	Second independent M1 for a correct method to give an equation in T *(t) only* using their **v**	
	A1 for (T) = ½	

Question Number	Scheme	Marks
3		
Method 1	Horizontal component $= 6 - 7\cos 60$ (N)	M1A1
	Vertical component (N) $= 7\cos 30$	M1A1
	Use Pythagoras: $\sqrt{2.5^2 + 6.06^2} = \sqrt{43} = 6.6$(N) or better	M1A1
	Use trig: angle = $\tan^{-1}(\frac{7\cos 30}{2.5}) = 68^o$(below **P**) or better Also allow 112^0, 292^0 or 248^0	M1A1
		(8)
Alt		
	Cosine rule to find $\|\mathbf{R}\|$: $R^2 = 36 + 49 - 2\times 6\times 7\times\cos 60 (= 43)$	M2 A2
	R = 6.6 (N) or better	M1 A1
	Solve Sine rule for θ: $\sin^{-1}(\frac{7\sin 60}{R})$	M1
	$= 68^o$ or better Also allow 112^0 or 292^0 or 248^0	A1
		[8]
	Notes	
Method 1	First M1 for attempt, allow sin/cos confusion, to find component parallel to **P**	
	First A1 for a correct expression	
	Second M1 for attempt, allow sin/cos confusion to find component perp to **P**	
	First A1 for a correct expression	
	Third M1 for using Pythag to find magnitude of **R**	
	Third A1 for √43, 6.6 (N) or better	
	Fourth M1 for complete method to find angle (M0 if 6 used for 'horiz' cpt) Fourth A1 for 68° or better (67.589089…) 112^0 or 292^0 or 248^0	

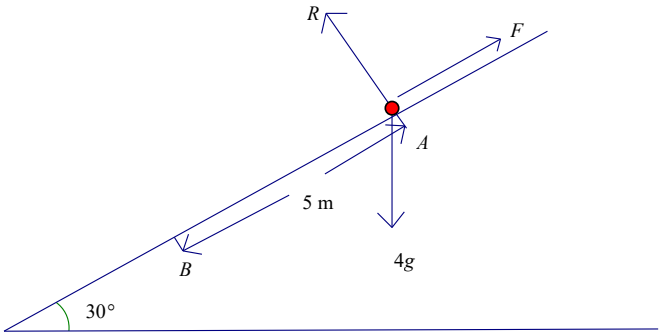
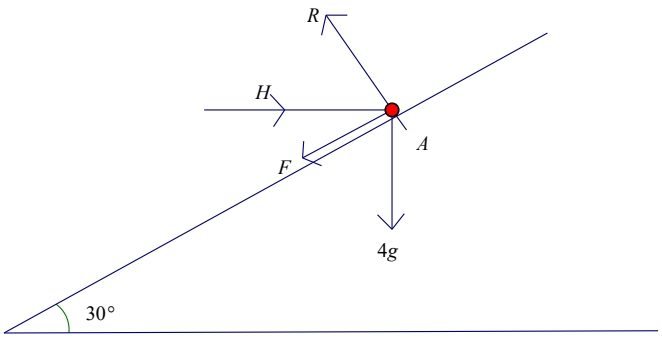
Question Number	Scheme	Marks
Alt	**Notes** First M2 for use of cosine rule with correct structure but allow $\cos 120^o$ and allow R^2 First A2 for a correct equation. (<u>A0 if 120^o used</u>) Third M1 for solving for R Third A1 for $\sqrt{43}$, 6.6 (N) or better Fourth M1 for complete method (e.g. sine rule) to find angle between their **R** and **P** Fourth A1 for 68^o or better	1

Question Number	Scheme	Marks
4a		
	Moments about D: $20g\times 2+8g\times 4.5=R_C\times 4.5$ **OR** Resolve: $R_C+R_D=28g$	M1A1
(i)	$R_C=\frac{152}{9}g\,(=166 \text{ or } 170)$	A1
	Moments about C: $20g\times 2.5=R_D\times 4.5$ **OR** Resolve: $R_C+R_D=28g$	M1A1
(ii)	$R_D=\frac{100}{9}g\,(=109 \text{ or } 110)$	A1
		(6)
4b		
	Moments about A: $R\times 1.5+2R\times 6=20g\times 4+8g\times x$	M1A1
	Resolve: $3R=28g$, $\left(R=\frac{28}{3}g\,(=91.5)\right)$	M1A1
	Substitute for R and solve for x: $\frac{27}{2}\times\frac{28}{3}g=80g+8g\times x$	M1
	$126=80+8x$, $8x=46$, $x=5.75\,(\text{m})$	A1
		(6)
4c	The weight of the package acts at point C (or E)	B1 (1)
		[13]
	Notes **N.B.** In both parts, enter marks on ePen for the *equations* as they appear **BUT** in part (a) second A1 is for R_C and fourth A1 is for R_D Remember to only penalise overaccuracy, after use of g, ONCE per whole question	

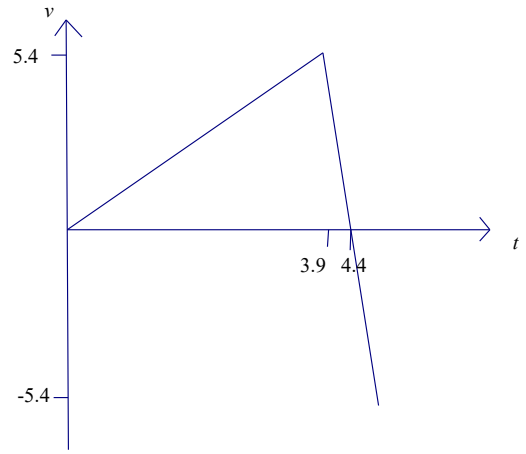
Question Number	Scheme	Marks
4a	**Omission of g is an A error in this part.** If answers are given as decimal multiples of g, penalise once If answers given as (fraction x g), fraction must be ratio of two integers First M1 for any moments equation (even if it contains both reactions) or vertical resolution First A1 for a correct equation Second A1 for $R_C = \frac{152}{9}g \left(= 166 \text{ or } 170\right)$ Second M1 for another moments equation (even if it contains both reactions) or vert resolution Third A1 for a correct equation Fourth A1 for $R_D = \frac{100}{9}g \left(= 109 \text{ or } 110\right)$	
4b **4c**	**Notes** **N.B. Consistent omission of g can score full marks in this part.** **If they use the values of the reactions from part(a), no marks for part b.** If *R* and 2*R* reversed, can score max M1A1 (vert res) M1A0 (mom about C or D) M1A0 First M1 for a moments equation in *R* and *x* only (*x* may not be *AE*) First A1 for a correct equation e.g. M(A) $R \times 1.5 + 2R \times 6 = 20g \times 4 + 8g \times x$ Second M1 for another moments equation in *R* and *x* only or vert resolution in *R* only Second A1 for a correct equation Third M1 for solving for *AE* Third A1 for 5.75 (m) (Must be EXACT) Mass or wt of package is or acts at (point) *C* (or *E*)	

Question Number	Scheme	Marks
5a		
	Attempt at difference in momenta for Q	M1
	$= \pm km(2u - -u)$	A1
	Magnitude $= 3kmu$	A1
		(3)
5b		
	First case e.g. P continues in the same direction CLM: $4m \times 3u - km \times u = 4m \times 2u + km \times 2u$ **OR** $-3kmu = 4m(2u - 3u)$	M1A1
	$k = \frac{4}{3}$, 1.33 (3 SF or better)	A1
		
	Second case e.g. P changes direction CLM: $4m \times 3u - km \times u = -4m \times 2u + km \times 2u$ **OR** $3kmu = 4m(2u - -3u)$	M1
	$k = \frac{20}{3}$, 6.67 (3 SF or better)	A1
		(5)
		[8]

Question Number	Scheme	Marks
	Notes	
5a	M1 for clear attempt at *difference* in momenta for Q only (M0 if mass omitted or if g's included or if clearly adding) in terms of k, m and u only.	
	First A1 for $\pm km(2u--u)$	
	Second A1 for $3kmu$	
5b	**N.B.** Mark the 'better' equation out of 3	
	First M1 for an equation in k, m and u *only*, dim. correct with correct no. of terms (4 if using CLM, or 3 if using impulse from part (a)) condone sign errors	
	First A1 for a correct equation	
	Second A1 for a correct value of k	
	Second M1 for another equation (**N.B**. Must clearly have P now moving in the opposite direction to that already considered) in k, m and u *only*, dim. correct with correct terms (4 if using CLM, or 3 if using impulse from part (a)) condone sign errors	
	Third A1 for the other correct value of k	

Question Number	Scheme	Marks
6a		
	Resolve perpendicular to plane: $R = 4g\cos 30$	B1
	$F = 0.3R$ seen	B1
	Use of $F = ma$ parallel to plane: $4a = 4g\sin 30 - F$	M1A1
	$4a = 4g\sin 30 - 0.3\times 4g\cos 30$	A1
	Use of $v^2 = (u^2 +)2as$: $v = \sqrt{(10a)}$	M1
	v = 4.9 or 4.85(m s^{-1})	A1
		(7)
6b		
	Resolve perpendicular to the plane: $R = 4g\cos 30 + H\cos 60$	M1A1
	Resolve parallel to the plane: $H\cos 30 = F + 4g\sin 30$	M1A1
	Use of $F = 0.3R$	M1
	Solve for H: $H = \dfrac{g(1.2\cos 30 + 4\sin 30)}{\cos 30 - 0.3\cos 60}$	**DM**1
	= 42 or 41.6	A1
		(7)
6b alt	Resolve vertically: $R\cos 30 = 4g + F\cos 60$	M1A1
	Resolve horizontally: $H = R\cos 60 + F\cos 30$	M1A1
	Use of $F = 0.3R$	M1
	Solve for H:	**DM**1
	H = 42 or 41.6	A1 (7)
	N.B. Enter marks on ePen for equations as they appear.	[14]

Question Number	Scheme	Marks
	Notes	
6a	First B1 for $R = 4g\cos 30$ Second B1 for $F = 0.3R$ seen (could just be on diagram) First M1 for equation of motion, with usual rules, condone sign errors First A1 for a correct equation (F not substituted) Second A1 for a correct equation in a only, without trig ratios substituted Second M1 for a complete method for finding v (must have found an a value) Third A1 for 4.9 or 4.85	
6b	First M1 for a resolution, with usual rules, condone sign errors First A1 for a correct equation Second M1 for another resolution, with usual rules, condone sign errors Second A1 for a correct equation Third M1 for use of (i.e. it must appear in an equation) $F = 0.3R$ (**N.B.** M0 if using R from part **a**) Fourth M1 **dependent** on first, second and third M's, for eliminating F and R and solving for H Third A1 for 42 or 41.6	

Question Number	Scheme	Marks
7a	Motion of P: $T - 3g = 3a$	M1
	$33.6 - 3g = 3a$	A1
	$a = 1.4$ (m s^{-2}) ***Given Answer***	A1
		(3)
7b	Motion of Q: $mg - T = ma$	M1
	$mg - 33.6 = 1.4m$	A1
	$m = 4$	A1
		(3)
7c	Use of $s = (ut +)\frac{1}{2}at^2$: $10.5 = \frac{1}{2} \times 1.4 \times t^2$	M1A1
	$T_1 = \sqrt{15} = 3.9$ or better	A1
		(3)
7d	Use $v^2 = (u^2 +)2as$ to find speed of particles when Q hits ground: $v = \sqrt{2 \times 1.4 \times 10.5}$ $(= \sqrt{29.4})$	M1
	Use $v = u + at$ to find additional time for P to come to rest: $0 = \sqrt{29.4} - gt$	**DM**1
	Total time : $T_2 = \sqrt{15} + \frac{\sqrt{29.4}}{9.8} = 4.4$ or 4.43	A1
		(3)
7e		B1 Shape **DB**1 **ft** their values for 5.4, -5.4, 3.9, 4.4 (or T_1 T_2) (2)
		[14]

Question Number	Scheme	Marks
	Notes	
7a	M1 for equation of motion for P with T not substituted, condone sign errors First A1 for a correct equation in a only (allow $\pm a$) Second A1 for **given answer** (units not needed)	
7b	M1 for equation of motion for Q with neither T nor a substituted, condone sign errors First A1 for a correct equation in m only Second A1 for $m = 4$ **N.B.** Whole system equn: $mg - 3g = a(m + 3)$ may be used	
7c	M1 for a complete method to find T_1 (M0 if g used) First A1 for a correct equation (or equations) Second A1 for $\sqrt{15}$, 3.9 or better $v = \sqrt{29.4}$ (5.4) may be found in this part but only gets credit if it appears in part (d)	
7d	First M1 for a complete method to find the speed of particles when Q hits the ground (M0 if using g) Second M1 **dependent** on first M1for a complete method to find the additional time for P to come to rest (must be using g) A1 for 4.4 or 4.43	
7e	First B1 (generous) for shape. Graph does not need to go down as far as it goes up and ignore gradients. (B0 if it goes outside the range $0 \leq t \leq T_3$ or if a continuous vertical line is included) Second **B**1, **dependent** on first B1, **ft** on their $\sqrt{29.4}$, T_1 and T_2 Allow T_1 and T_2 entered on the graph (rather than their numerical values)	