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Mark Scheme (Results)

Summer 2015

Pearson Edexcel GCE in Mechanics 1 (6677_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.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE 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
1(a)	$m.5u - kmu = -\frac{m.5u}{2} + \frac{km.u}{2}$ $k = 5$	M1 A1 A1 (3)
(b)	For $P: I = m\left(\frac{5u}{2} - -5u\right)$ OR For $Q: I = km\left(\frac{u}{2} - -u\right)$ $= \frac{15mu}{2}$ $= \frac{15mu}{2}$	M1 A1 A1 (3) **6**
	Notes	
1(a)	M1 for attempt at CLM equation, with correct no. of terms, dimensionally correct. Allow consistent extra g's and cancelled m's and u's and sign errors. First A1 for a correct equation with or without m's and u's Second A1 for $k = 5$ **N.B.** They may find the impulse on each particle and then equate the impulses to produce an equation. Apply the scheme to this equation.	
1(b)	M1 for attempt at impulse = difference in momenta, for either particle, (must be considering *one* particle) (M0 if g's are included or if m or u omitted) Allow $\pm m(\frac{5}{2}u - 5u)$ or $\pm km(\frac{1}{2}u - u)$. First A1 for $\pm m(\frac{5}{2}u - -5u)$ or $\pm km(\frac{1}{2}u - -u)$ A1 for $7.5mu$ oe cao ($-7.5mu$ is A0) Allow change of sign at end to obtain magnitude	

Question Number	Scheme	Marks
2(a)	$0^2 = 19.6^2 - 2 \times gH$ $H = 19.6\text{m}$ (20)	M1 A1 (2)
(b)	$14.7 = 19.6t - \frac{1}{2}gt^2$ $t^2 - 4t + 3 = 0$ $(t-1)(t-3) = 0$ $t = 1$ or 3; Answer 2 s	M1 A1 **DM**1 A1; A1 (5) **7**
2(b) **ALT 1**	(their h - 14.7) = ½ g t^2 **OR** $v^2 = 19.6^2 - 2$g x 14.7 => v = (±) 9.8 t =1 and 0 9.8 – 9.8 t => t = 1 Total = 2 x their 1 = 2 s	M1 A1 A1 **DM** 1 A1
2(b) **ALT 2/3**	$v^2 = 19.6^2 - 2$g x 14.7 $v = \pm 9.8$ **EITHER:** - 9.8 = 9.8 – gT $T = 2$ **OR:** 0 = 9.8t - ½ g t^2 t = (0) or 2	M1 A1 **DM**1 A1 A1 **DM**1 A1 A1
	Notes	
2(a)	M1 is for a complete method (which could involve use of two *suvat* equations) for finding H i.e. for an equation in H *only*, condone sign errors A1 for 19.6 or 20 correctly obtained (2g is A0)	
2(b)	First M1 is for a quadratic equation in t only (where t is time at 14.7 above O) First A1 for a correct equation Second DM1, dependent on first M1, for solving for t Second A1 for both values of t , 1 and 3. **N.B**. If answer(s) are wrong or have come from an incorrect quadratic, and the quadratic formula has been used, M1 can only be awarded if there is clear evidence that the correct formula has been used. If their expression is not correct for their quadratic, allow a slip but only if we see an attempt to substitute into a stated correct formula. Third A1 for 2 s **N.B.** Obtaining t = 1 at s = 14.7 (above O) only, can score max M1 A1	

Question Number	Scheme	Marks
3	$T_P \cos 55 = T_Q \cos 35$ $T_P \sin 55 + T_Q \sin 35 = 2g$ Eliminating T_P or T_Q $T_P = 16\text{N}$ or 16.1N; $T_Q = 11\text{N}$ or 11.2N	M1 A1 M1 A1 M1 A1 A1 **7**
ALT 1	$\left(\text{Along } RP\right)\ T_P = 2g\cos 35° = 16\text{N}$ or 16.1N $\left(\text{Along } RQ\right)\ T_Q = 2g\cos 55° = 11\text{N}$ or 11.2N	M1 M1 A1 A1 M1 A1 A1
	Notes	
	First M1 for resolving horizontally with correct no. of terms and both T_P and T_Q terms resolved. (M0 if they assume $T_P = T_Q$) First A1 for a correct equation. Second M1 for resolving vertically with correct no. of terms and both T_P and T_Q terms resolved. (M0 if they assume $T_P = T_Q$) Second A1 for a correct equation. Third M1 (independent) for eliminating either T_P or T_Q Third A1 for T_P = 16 (N) or 16.1 (N) Fourth A1 for T_Q = 11 (N) or 11.2 (N) N.B. If both are given to more than 3SF, deduct the third A1.	
ALT 1	**Alternative 1 (resolving along each string)** First M2 for resolving along one of the strings (e.g. $T_P = 2g\cos 35^o$) First A1 for a correct equation ($T_P = 2g\sin 35^o$ scores M2A0A0) Third A1 for T_P = 16 (N) or 16.1 (N) Third M1 for resolving along the other string (e.g. $T_Q = 2g\cos 55^o$) Second A1 for a correct equation ($T_Q = 2g\sin 55^o$ scores M1A0A0) Fourth A1 for T_Q = 11 (N) or 11.2 (N)	
ALT 2	**Alternative 2 (using a Triangle of Forces)** Both of the equations in Alternative 1 could come from using *sohcahtoa* or The Sine Rule on a triangle of forces, so mark in the same way. Note that, in either case, once they have found either T_P or T_Q , they could then use $T_P = T_Q \tan 55^o$ or $T_Q = T_P \tan 55^o$ to find the other one. (Note that both of these are equivalent to the horizontal resolution) or Pythagoras. e.g. $T_P = 2g\cos 35^o$ M2 First A1 = 16 (N) or 16.1 (N) Third A1 $T_Q = T_P \tan 35^o$ or $\sqrt{\{(2g)^2 - (T_P)^2\}}$ M1 Second A1 = 11 (N) or 11.2 (N) Fourth A1	

	N.B. If they are clearly using The Sine Rule but have say 35^o, 55^o and 80^o in their triangle, all 3 M marks would be available and at most 1 A mark e.g. $T_P = \frac{2g\sin 55}{\sin 80}$ M2 A0A0 $T_Q = \frac{T_P \sin 35}{\sin 55}$ M1 SecondA1 A0	

Question Number	Scheme	Marks
4(a)	For crate, $55g - 473 = 55a$ $a = 1.2 \text{m s}^{-2}$	M1 A1 A1 (3)
(b)	For system, $55g + 200g \pm T - 150 = 255a$ Magnitude $= 2040$ N or 2000 N OR For lift, $200g + 473 - 150 \pm T = 200a$ Magnitude $= 2040$ N or 2000 N	M1 A2 A1 M1 A2 A1 (4) **7**
	Notes	
4(a)	M1 for an equation in a only, with usual rules. First A1 for a correct equation Second A1 for 1.2 (m s^{-2}). Allow – 1.2 (m s^{-2}) if appropriate	
4(b)	M1 for an equation, in T and a , for the system or the lift only, with usual rules. (a does not need to be a numerical value) A2 (-1 each error) for a correct equation (**Allow** $\pm T$). We do **not** need to see a numerical value for a. Third A1 for 2040 (N) or 2000 (N) **N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered.	

Question Number	Scheme	Marks
5(a)	$T_A + T_C = 85g$ OR $M(A),\ 25g \times 2.5 + 60g \times 5 = 4.5 \times T_C$ OR $M(C),\ T_A \times 4.5 + 60g \times 0.5 = 25g \times 2$ OR $M(B),\ T_A \times 5 + T_C \times 0.5 = 25g \times 2.5$ OR $M(G),\ T_A \times 2.5 + 60g \times 2.5 = 2 \times T_C$ $T_A = \frac{40g}{9} = 44\text{N}$ or 43.6N; $T_C = \frac{725g}{9} = 790\text{N}$ or 789 N	M1 A1 M1 A1 A1; A1 (6)
(b)	$\text{M}(C),\ 25g \times 2 = Mg \times 0.5$	M1 A1
(i)	$M = 100$	A1
(ii)	$T_c = 25g + 100g$ $T_c = 125g\ (1200 \text{ or } 1230)\text{N}$	M1 A1 B1 (6) **12**
	Notes	
5(a)	First M1 for a moments or vertical resolution equation, with correct no. of terms and dimensionally correct. First A1 for a correct equation. Second M1 for a moments equation, with correct no. of terms and dimensionally correct. Second A1 for a correct equation. Third A1 for 44 (N) or 43.6 (N) or 40g/9 Fourth A1 for 790 (N) or 789 (N) or 725g/9 Deduct 1 mark for inexact multiples of g **N.B.** If they assume that both tensions are the same, can only score max M1 in (a) for *M(A)* or *M(C)*. If a vertical resolution is used, please give marks for this equation FIRST. If not, enter marks for each moments equation in the order in which they appear.	
5(b)	**SCHEME CHANGE** B1 BECOMES THE FOURTH A1 First M1 for a moments equation with $T_A = 0$ First A1 for a correct equation Second A1 for $M = 100$ Second M1 for a(nother) moments or vertical resolution equation with $T_A = 0$ Third A1 for a correct equation Fourth A1 (B1) for $T_C = 125g$ or 1230 (N) or 1200 (N) *N.B. Some candidates may need to solve 2 simult. equations in M and T_C and so will earn the 'equation' marks before they earn Second and Fourth A (B) marks.* If a vertical resolution is used, please give marks for this equation SECOND. If not, enter marks for each moments equation in the order	

	in which they appear. The possible equations are: $T_C = 25g + Mg$ M(C), $25g$ x 2 = Mg x 0.5 M(A), $25g$ x 2.5 + $5Mg$ = 4.5 T_C M(B), $25g$ x 2.5 = T_C x 0.5 M(G), T_C x 2 = Mg x 2.5 Any two of these can each earn M1A1 (M0 if incorrect no. of terms) Then Second A1 for $M = 100$ And Fourth A1 (B1) for T_C = 125g or 1230 or 1200 **N.B.** No marks in (b) if they use any answers from (a) or $M = 60$	

Question Number	Scheme	Marks
6(a)	$\mathbf{r} = (-3\mathbf{i} + 4\mathbf{j})$ m	B1 (1)
(b)	$3.4 = 2T - 3$ or $-12 = 4 - 5T$ $T = 3.2$	M1 A1 A1 (3)
(c)	$\mathbf{r} = (-3\mathbf{i} + 4\mathbf{j}) + t(2\mathbf{i} - 5\mathbf{j})$ $\mathbf{v} = (2\mathbf{i} - 5\mathbf{j})$ speed $= \sqrt{\left(2^2 + (-5)^2\right)} = \sqrt{29} = 5.4\text{m s}^{-1}$ or better	M1 A1 M1 A1 (4) **8**
Alt (c)	$\lvert\mathbf{s}\rvert = \sqrt{6.4^2 + (-16)^2} = 17.23...$ $\therefore$ speed $= \dfrac{17.23}{3.2} = 5.4$ or better	M1 A1 M1 A1 (4)
	Notes	
6(a)	**Allow column vectors throughout.** B1 for $(-3\mathbf{i} + 4\mathbf{j})$ (m)	
(b)	M1 for a clear attempt at either 3.4 (**i**)= $(2T - 3)$ (**i**) or -12(**j**) = $(4 - 5T)$ (**j**) First A1 for a correct equation (either) without **i**'s and **j**'s A1 for 3.2 oe **N.B.** $T = \dfrac{6.4\mathbf{i} - 16\mathbf{j}}{2\mathbf{i} - 5\mathbf{j}} = 3.2$ scores M1A1A1 BUT if RHS is not a single number, then M0. Also, if they get 3.2 and another value and don't clearly choose 3.2 then A0	
(c)	First M1 for a complete method for finding **v** e.g. $\mathbf{r} = (-3\mathbf{i} + 4\mathbf{j}) + t(2\mathbf{i} - 5\mathbf{j})$ so $\mathbf{v} = 2\mathbf{i} - 5\mathbf{j}$ OR: $\mathbf{v} = \dfrac{(3.4\mathbf{i} - 12\mathbf{j}) - (-3\mathbf{i} + 4\mathbf{j})}{\text{their } T}$ OR: $\mathbf{v} = \dfrac{\mathrm{d}\mathbf{r}}{\mathrm{d}t} = 2\mathbf{i} - 5\mathbf{j}$ First A1 for $2\mathbf{i} - 5\mathbf{j}$; M1A1 can be awarded for $2\mathbf{i} - 5\mathbf{j}$ only. Second M1 for attempt to find magnitude of their **v**, i.e. $\sqrt{2^2 + (-5)^2}$ Second A1 for √29 or 5.4 or better **OR** First M1 for attempt to find distance travelled: $d = \sqrt{(-3 - 3.4)^2 + (4 - -12)^2}$ First A1 if correct Second M1 for their d / their T Second A1 for √29 or 5.4 or better	

Question Number	Scheme	Marks
7(a)		B1 (shape) B1 (V) (2)
(b) **(i) (ii)**	$\frac{V}{t_1}=\frac{1}{2} \Rightarrow t_1=2V$ s; $t_2=4V$ s	M1 A1; A1
(iii)	$t_3=300-2V-4V=300-6V$ s	M1 A1 (5)
(c)	$6300=\frac{V(300+300-6V)}{2}$ or $\frac{1}{2}2V.V+(300-6V).V+\frac{1}{2}4V.V$ $V^2-100V+2100=0$ $(V-30)(V-70)=0$ $V=30$ or 70 $V=30\ (<50)$	M1 **A1 ft** A1 M1 A1 A1 (6) **13**
	Notes	
7(a)	B1 for a trapezium with line starting and finishing on the t-axis B1 for V correctly marked	
(b)	First M1 for a correct method First A1 for $V/0.5$ oe Second A1 for $V/0.25$ oe Second M1 for (300 – sum of previous answers) Allow 5 instead of 300. Third A1 for $300-6V$ oe	
(c)	First M1 for using the area under the curve (distance travelled) to form an equation in V only. (Allow use of 6.3 but must see ½ used at least once in their expression.) First A1 **ft on their answers in (b)** for a correct equation so must have used 6300 not 6.3 Second A1 for correct equation in form $aV^2+bV+c=0$ Second M1 for solving a 3 term quadratic. (Can be implied by correct answers) Second A1 for either 30 or 70	

	Third A1 for 30 as final answer. **N.B**. If answer(s) are wrong or have come from an incorrect quadratic, and the quadratic formula is used, M1 can only be awarded if there is clear evidence that the correct formula has been used. i.e. we need to see numbers substituted into a stated correct formula.	

Question Number	Scheme	Marks
8(a)	$R = 4g\cos\alpha$	M1 A1
	$T - 0.5g = 0.5a$	M1 A1
	$4g\sin\alpha - T - F = 4a$	M1 A1
	(OR: $4g\sin\alpha - F - 0.5g = 4.5a$)	
	$F = \frac{1}{2}R$; $\sin\alpha = \frac{4}{5}$ or $\cos\alpha = \frac{3}{5}$	B1; B1
	Eliminating a or finding a	M1
	Solving for T (must have had an a)	M1
	$T = \frac{2g}{3}$ N or 6.5N or 6.53N	A1
		(11)
(b)	Magnitude $= 2T\cos\left(\frac{90-\alpha}{2}\right)$	M1 A1
	$= 2 \text{ x } \frac{2g}{3} \text{ x } \frac{3}{\sqrt{10}}$ (0.94868..)	**A1 ft on *T***
	$= 12N$ or $12.4N$ $\left(\frac{4g}{\sqrt{10}}\right)$	A1 (4)
		15
	Notes	
8(a)	First M1 for resolving perp to plane, with usual criteria First A1 for a correct equation Second M1 for resolving vertically, with usual criteria Second A1 for a correct equation, in terms of a and T Third M1 for resolving parallel to the slope, with usual criteria. Third A1 for a correct equation , in terms of a, F and T N.B. Their a could be UP the slope in which case all 4 marks for the 2 equations are available with $-a$ replacing a, provided they are consistent. If they are inconsistent, then assume the vertical resolution is the correct one and mark accordingly. Either of the above two equations can be replaced by the 'whole system' equation **N.B. If they use a = 0, in any of the above 3 equations, and they use the equation to find T, they lose both marks for that equation, and they lose the two M marks for eliminating and solving.** First B1 for $F = \frac{1}{2}R$ seen or implied; Second B1 for $\sin\alpha = 0.8$ or $\cos\alpha = 0.6$ seen or implied. Allow close approximations if $\alpha = 53.1^{\circ}\ldots$ used. Fourth M1 independent for eliminating a or finding a. Fifth M1 for solving for T but must have had an a. Fourth A1 for 2g/3, 6.5 or 6.53.	

(b)	First M1 for a complete method for finding the magnitude of the resultant (**N.B.** M0 if same tensions used) $2T\cos\left(\frac{90^\circ-\alpha}{2}\right)$ .Allow sin/cos confusion and allow $2T\cos\left(\frac{\alpha}{2}\right)$ **OR** $\sqrt{(T+T\sin\alpha)^2+(T\cos\alpha)^2}$. Allow sin/cos confusion and allow omission of √ sign, but only if R^2 = ……. is included **OR** $\sqrt{T^2+T^2-2T^2\cos(90^\circ+\alpha)}$**.** Allow $(90^\circ-\alpha)$ but must be cos and and allow omission of √ sign, but only if R^2 =…….is included **OR** $\frac{T\sin(90+\alpha)}{\sin\left(\frac{90^\circ-\alpha}{2}\right)}$**. (Sine Rule)** Allow sign errors in angles but must be sin First A1 for correct expression in terms of T and α Second A1, **ft** on their T, for a 'correct' **single numerical** answer Third A1 cao for 12 (N) or 12.4 (N)	

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