Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE
Mechanics M1 (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.
- 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 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

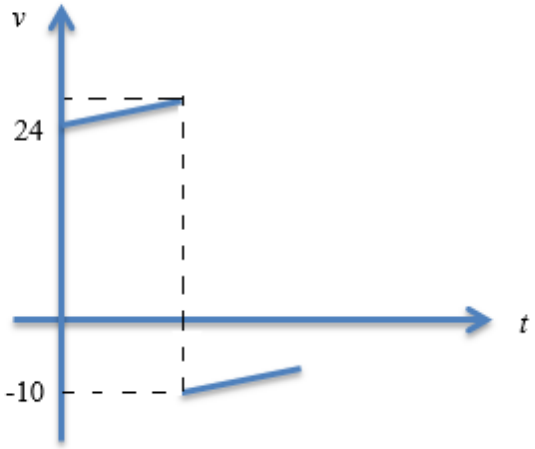
  PCLM Principle of conservation of linear momentum

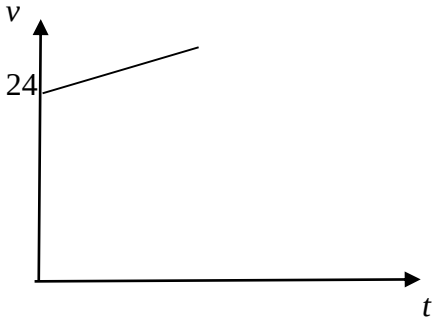
  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1(a)	For P: $-\frac{21mu}{4} = 3m(v_P - 2u)$	M1A1
	$v_P = \frac{u}{4}$	A1 (3)
(b)	For Q: $\frac{21mu}{4} = m(v_Q - -4u)$	M1A1
	$v_Q = \frac{5u}{4}$	A1 (3)
OR	CLM: $3m \times 2u - m \times 4u = 3m \times \frac{u}{4} + mv_Q$ M1 A1	
	$v_Q = \frac{5u}{4}$ A1	
		(6)
	Notes for Qu 1	
	1(a) M1 for using Impulse = Change in Momentum of P (must have 3m in both terms) (M0 if *clearly* adding momenta or if g is included) but condone sign errors. First A1 for a correct equation. (N.B. Could have $-v_P$ in place of v_P) Second A1 for $\frac{u}{4}$ oe (must be positive) **N.B.** If they try to find v_Q first and then use CLM to find v_P, M1 for a complete method to find v_P, A1 for correct equations, A1 for the answer for v_P. If an incorrect v_Q is then just stated in (b), award relevant marks if seen in working for (a). If no attempt at (b), then no marks for (b).	
	1(b) M1 for using Impulse = Change in Momentum of Q (must have m in both terms) (M0 if *clearly* adding momenta or if g is included) but condone sign errors. First A1 for a correct equation. (N.B. Could have $-v_Q$ in place of v_Q) Second A1 for $\frac{5u}{4}$ oe (must be positive) **OR**: M1 for CLM with correct no. of terms, condone missing m's or extra g's and sign errors First A1 for a correct equation Second A1 for $\frac{5u}{4}$ oe (must be positive)	

Question Number	Scheme	Marks
2.	(Parallel to plane): $P\cos 50 + F = 2g\cos 60$	M1 A2
	(Perp to plane): $R - P\sin 50 = 2g\cos 30$	M1 A2
	Other possible equations:	
	$(\rightarrow): R\cos 60 - F\cos 30 = P\cos 20$ M1 A2	
	$(\uparrow): R\cos 30 + F\cos 60 = P\cos 70 + 2g$ M1 A2	
	$F = \frac{1}{4}R$	B1
	Attempt to eliminate *F* and *R* to give an equation in *P* only	M1
	Solve for *P*	**DM**1
	P = 6.7 (2 SF) or 6.66 (3SF)	A1
		(10)
	Notes for Qu 2	
	2. First M1 for resolving parallel to the plane with usual rules. 2*g* term must be using 30º or 60º angle but allow sin/cos confusion. First and second A1's for a correct equation. A1A0 if one error. Second M1 for resolving perpendicular to the plane with usual rules. 2*g* term must be using 30º or 60º angle but allow sin/cos confusion. Third and fourth A1's for a correct equation. A1A0 if one error. B1 for *F* = ¼ *R* seen or implied Third M1, independent but must have two 3 (or 4) term equations, for attempt to eliminate *F* and *R* to give an equation in *P* only. Fourth DM1, dependent on third M1, for solving for *P*. Fifth A1 for 6.7 or 6.66 **Other possible equations**: First M1 for resolving horizontally with usual rules. *R* term must be using 30º or 60º angle and *F* term must be using 30º or 60º angle but allow sin/cos confusion. First and second A1's for a correct equation. A1A0 if one error. Second M1 for resolving vertically with usual rules. *R* term must be using 30º or 60º angle and *F* term must be using 30º or 60º angle but allow sin/cos confusion. Third and fourth A1's for a correct equation. A1A0 if one error.	

Question Number	Scheme	Marks
3.(a)	$M(D),\ (150g\times 1)+(60g\times 2.5)=Tc\times 4$	M1 A1
	$Tc=75g$ or 735 N or 740 N Allow omission of N	A1 (3)
(b)	$M(B),\ (150g\times 4.5)+(60g\times 6)=T_D\times 3.5$	M1 A2
	$T_D=2900$ N or $\frac{2070g}{7}$ Allow omission of N	A1 (4)
		(7)
	Notes for Qu 3	
	3(a) M1 for a complete method to find Tc (M0 if they assume $T_C = T_D$) i.e. for producing an equation in Tc only. Each equation used must have correct no. of terms and be dimensionally correct. First A1 for correct equation. Second A1 for any of the 3 possible answers Other possible equations: $(\uparrow),Tc+T_D=60g+150g$ $M(A),\ (150g\times 4.5)+(60g\times 3)=(Tc\times 1.5)+(T_D\times 5.5)$ $M(C),\ (150g\times 3)+(60g\times 1.5)=T_D\times 4$ $M(B),\ (150g\times 4.5)+(60g\times 6)=(Tc\times 7.5)+(T_D\times 3.5)$ $M(G),\ (T_D\times 1)+(60g\times 1.5)=T_C\times 3$	
	3(b) **N.B.** (M0 if T_C is never equated to 0) M1 for a complete method to obtain an equation in T_D only. If they use more than one equation, each equation used must have correct no. of terms and be dimensionally correct. First and second A1 for a correct equation in T_D only. A1A0 if one error.Consistent omission of g is one error except in *M(D)* where it's not an error. Third A1 for either answer Other possible equations: $(\uparrow),T_D=60g+150g+Mg$ $M(A),\ (150g\times 4.5)+(60g\times 3)+9Mg=T_D\times 5.5$ $M(C),\ (150g\times 3)+(60g\times 1.5)+7.5Mg=T_D\times 4$ $M(D),\ (150g\times 1)+(60g\times 2.5)=3.5Mg$ $M(G),\ (T_D\times 1)+(60g\times 1.5)=4.5Mg$	

Question Number	Scheme	Marks
4.(a)	$V^2 = U^2 + 2g \times 2.5$	M1A1
	Eliminate V *and* solve for U	A1 **(DM1)**
	$7 = 0.2(10 - -V)$	M1A1
	$U = 24$	A1 (6)
4.(b)	$1 = 10t - 4.9t^2$ **OR** e.g. $v^2 = 10^2 - 2 \times 9.8 \times 1$ and $v = 10 - 9.8t$	
	$1 = 10t - 4.9t^2$ to give $\sqrt{80.4} = 10 - 9.8t$	M1 A1
	$t = \dfrac{10 \pm \sqrt{100 - 19.6}}{9.8}$ so $t = \dfrac{10 - \sqrt{10^2 - 2 \times 9.8 \times 1}}{9.8}$	**DM**1
	$t = 0.11$ s or 0.105 s	A1 (4)
4(c)		B1**ft**1st line B1 2nd line B1 ,-10 (3)
		(13)
	Notes for Qu 4	
	4(a) First M1 for complete method, using *suvat*, to find equation in U and V only First A1 for a correct equation Second A1 – **treat as third DM1**, dependent on the other two M's, for eliminating V and solving for U Second M1 for using Impulse = Change in Momentum of ball (must have 0.2 in both terms and be using 10 as one of the velocities) (M0 if *clearly* adding momenta or if g is included) but condone sign errors. Third A1 for a correct equation, 7 and 10 must have the same sign but equation may have V instead of $-V$ Fourth A1 for $U = 24$ (must appear here) **N.B.** If they use U instead of V in the impulse-momentum equation, can score max M1A0/6 for part (a). **N.B.** If they go from $V^2 = U^2 + 49$ to $V = U + 7$, can score max 5/6	

	4(b) First M1 for complete method, using one or more *suvat* formulae, to produce an equation in *t* only <u>using *s* = 1 or -1</u> First A1 for a correct equation in *t* only Second DM1, dependent on first M1, for solving their equation (this mark can be implied by a correct answer) Second A1 for either 0.105 (s) or 0.11 (s) (must be only ONE answer)	
	4(c) First B1**ft** for a straight line, with positive gradient, starting at their *U* value (or just at *U*) on the positive *v*-axis. Second B1 for a parallel (approx.) line placed correctly (<u>B0 if a continuous vertical line is included)</u> i.e. starting at a point where the *t* coordinate is equal to the *t* coordinate of the point where the first line stopped, and the *v* coordinate is negative. Third B1 for second line, placed correctly, starting on $v = -10$ N.B. Whole graph could be reflected in the *t*-axis **SC: If second line is placed correctly but extends up to the *t*-axis, or beyond, lose second B1 but can score the third B1.**	
4(b)	**ALTERNATIVE :** "the instant when the ball first passes through *B*" is taken to be when the ball is on the way down from *A*.	
	$s = vt - \frac{1}{2}at^2$ **OR** $v_B^{\,2} = 24^2 + 2\times 9.8\times 1.5$ and $25 = v_B + 9.8t$	
	$1 = 25t - 4.9t^2$ to give $25 = \sqrt{605.4} + 9.8t$	M1 A1
	$t = \frac{25 \pm \sqrt{625 - 19.6}}{9.8}$ so $t = \frac{25 - \sqrt{625 - 19.6}}{9.8}$	**DM1**
	$t = 0.040$ (s) or 0.0403 (s) or 0.04 (s) (must only be ONE answer)	A1 (4)
4(c)	**ALTERNATIVE :** again "when it first passes through *B*" is taken to be when the ball is on the way down from *A*.	
		B2 line B1**ft** 24 (3)

	Notes for Qu 4 continued	
	4(b) First M1 for complete method, using one or more *suvat* formulae, to produce an equation in t only <u>using s = 1 or -1</u> First A1 for a correct equation in t only Second DM1, dependent on first M1, for solving their equation (this mark can be implied by a correct answer) Second A1 $t = 0.040$ (s) or 0.0403 (s)	
	4(c) B2 for a straight line, with positive gradient, starting on the positive v-axis. B1**ft** starting at their U value (or just at U)	

Question Number	Scheme	Marks
5(a)	$R - 60g = 60 \text{ x } 2$	M1A1
	$R = 708$ N or 710 N (must be positive)	A1 (3)
5(b)	$75n$	B1
	$10000 - Mg - 100 = M \times 3$	M1A2
	using $M = 250 + 75n$ => $n = 6.9..$	**DM1**A1
	so 6 people	A1**ft** (7)
		(10)
	Notes for Qu 5	
	5(a) M1 for equation in R only, with usual rules First A1 for a correct equation Second A1 for 710 or 708 (N not needed)	
	5(b) B1 for $75n$ oe seen or implied First M1 for an equation in one unknown in the form $10000 - Mg - 100 = M \times a$ with usual rules (must be using 10000) where M can be any (relevant) number e.g. 250, 75, etc First A1 and second A1 for a correct equation with $a = 3$, A1A0 if one error (e.g. Use of $a = 2$ loses 1 A mark) Second **DM1**, dependent on first M1, for using $M = 250 + 75n$ and solving for n Third A1 for 6.9… (A0 for 7) Fourth A1**ft** for no. of people, ft on their n value (A0 for < 7) **N.B.** If no incorrect work seen, the third A mark can be implied by a correct answer ($n = 6$) **SC:** They may use Trial and Error to find the critical value of n, by writing down equations for the tension when $n = 1, 2, 3, \ldots$ until the tension exceeds 10000 oe This method can score the final DM1 A1 A1 if done fully correctly up to and including $n = 7$, with a correct answer given. It could also score some or all of the first 4 marks.	

Question Number	Scheme	Marks
6.(a)	$(4\mathbf{i}-6\mathbf{j})+(p\mathbf{i}+q\mathbf{j})=(4+p)\mathbf{i}+(q-6)\mathbf{j}$	M1
	$\frac{(4+p)}{(q-6)}=\frac{2}{1}$ or $-\frac{2}{1}$ **(or** $\frac{1}{2}$ or $-\frac{1}{2}$)	**DM**1 A1
	$2q-12=4+p$	
	$p-2q=-16$ GIVEN ANSWER	**DM**1 A1 (5)
(b)	$q=3 \Rightarrow p=-10$	B1
	EITHER $0.5\mathbf{a}=-6\mathbf{i}-3\mathbf{j}$ **OR** $\lvert\mathbf{R}\rvert=\sqrt{(-6)^2+(-3)^2}$	M1
	$\mathbf{a}=-12\mathbf{i}-6\mathbf{j}$ = $\sqrt{45}$ oe	A1
	$\lvert\mathbf{a}\rvert=\sqrt{(-12)^2+(-6)^2}$ $0.5a=\sqrt{45}$	M1
	a = $\sqrt{180}=13.4\text{ms}^{-2}$ a = $\sqrt{180}=13.4\text{ms}^{-2}$	A1 (5)
(c)	e.g. $\tan\theta=\frac{12}{6} \Rightarrow \theta=63.4^\circ$	M1A1
	Bearing $=180^\circ+63.4^\circ=243^\circ$ (nearest degree)	A1cao (3)
		(13)
	Notes for Qu 6	
	Allow column vectors throughout	
	6(a) First M1 for adding the two forces, with **i's** and **j**'s collected, seen or implied Second DM1, dependent on first M1, for an equation in p and q only. Allow $\frac{1}{2}$ or -$\frac{1}{2}$ or -$\frac{2}{1}$ instead of $\frac{2}{1}$ First A1 for a correct equation in any form Third DM1, dependent on the second M1, for (at least)one **correct** intermediate line of working Second A1 for correct **given answer**	
	6(b) B1 for $p=-10$ seen or implied **EITHER** First M1 for use of $\mathbf{F}=0.5\mathbf{a}$ with their <u>resultant force (must be a sum of the two forces)</u> First A1 for $\mathbf{a}=-12\mathbf{i}-6\mathbf{j}$ Second M1 (independent) for finding magnitude of their **a** Second A1 for $\sqrt{180}$ oe or 13.4 or better	

	OR First M1 for finding the magnitude of their resultant force **R** (must be a sum of the two forces) $R = \sqrt{(-6)^2 + (-3)^2}$ First A1 for $\sqrt{45}$ oe Second M1 for using $R = 0.5a$ to find a Second A1 for $a = 2\sqrt{45}$ oe 13.4 ms^{-2} or better	
	6(c) M1 for use of a relevant trig ratio from their **a** or their **R (may not be the sum of the two forces) or** $-2\mathbf{i} - \mathbf{j}$ First A1 for any relevant correct angle coming from a correct **a** or **R** or from $-2\mathbf{i} - \mathbf{j}$ Second A1 for 243	

Question Number	Scheme	Marks
7(a)	Inextensible string	B1 (1)
	MARK PARTS (b) and (c) together	
(b)	$4mg\sin\alpha - T - F = 4ma$	M1 A2
	$T - mg = ma$	M1 A1 (5)
(c)	$F = \frac{1}{4}R$	B1
	$R = 4mg\cos\alpha$	B1
	$\cos\alpha = \frac{4}{5}$ or $\sin\alpha = \frac{3}{5}$	B1
	Eliminating R, F and T	M1
	$a = \frac{3}{25}g = 1.2$ or $1.18\ (\text{m s}^{-2})$	A1 (5)
(d)	$v^2 = 2\times\frac{3}{25}gh = \frac{6}{25}gh$	M1
	$0^2 = \frac{6}{25}gh - 2gs$	
	$s = \frac{3}{25}h$	M1 A1
	$d > \frac{3}{25}h + h = \frac{28}{25}h$ GIVEN ANSWER	**DM**1 A1 (5)
		(16)
	Notes for Qu 7	
	7(a) B1 for inextensible (and taut) string; B0 if any extras given or if an incorrect consequence of the inextensiblity of the string is given.	
	MARK PARTS (b) and (c) together **7(b)** **N.B.** Omission of *m* is a Method error i.e. M0 for that equation First M1 for equation of motion for *P* with usual rules (omission of 4 on RHS is M0) First A1 and second A1 for a correct equation, A1A0 if one error Second M1 for equation of motion for *Q* with usual rules Third A1 for a correct equation Use of e.g cos(4/5) instead of $\cos\alpha$ is an A error unless they recover correctly. N.B. Allow consistent use of $-a$	
	7(c) First B1 for $F = \frac{1}{4}R$ seen or implied Second B1 for $R = 4mg\cos\alpha$ seen or implied Third B1 for $\cos\alpha = \frac{4}{5}$ or $\sin\alpha = \frac{3}{5}$ seen or implied or an appropriate correct angle is used to give a correct trig ratio First M1 for eliminating *R*, *F* and *T* and finding an *a* value First A1 $a = \frac{3}{25}g = 1.2$ or $1.18\ (\text{m s}^{-2})$ (must be positive)	

	7(d) First M1 for finding v or v^2 for P using their a (M0 if g is used) Second M1 for a complete method to find s, independent but must have found v or v^2 (M0 if g not used) First A1 for $s = \frac{3}{25}h$ oe Third DM1, dependent on previous two M's, for adding h onto their s oe Second A1 for GIVEN ANSWER	

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