Mark Scheme (Results)

Summer 2019

Pearson Edexcel GCE In Mechanics
Paper 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.
- 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.

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: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. 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.

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

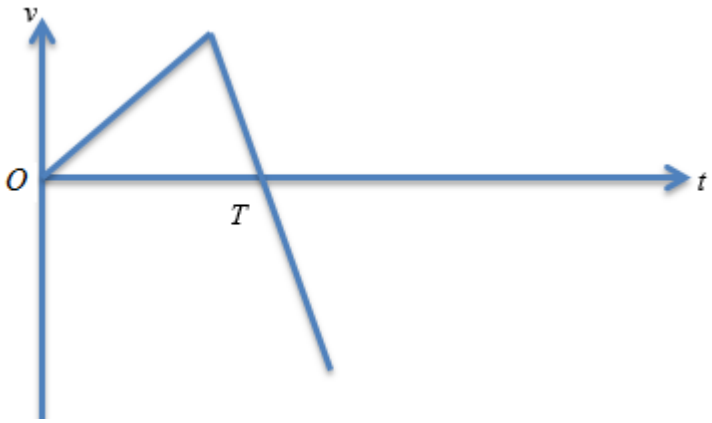
  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1(a)	$\tan q = \frac{3}{1}$ $q = 71.565^{o}..$ Bearing is 162^{o} (nearest degree)	M1 A1 A1 (3)
(b)	$(p\mathbf{i} + 2\mathbf{j}) + (3\mathbf{i} - q\mathbf{j}) + (q\mathbf{i} + 2p\mathbf{j}) = 2(\mathbf{i} - 3\mathbf{j})$ $p + q + 3 = 2$ $2p - q + 2 = -6$ $p = -3,\ q = 2$	M1 M1 M1 A1; A1 (5)
		(8)
	Notes	
	Accept use of column vectors	
1(a)	M1 for finding a relevant angle e.g. $\tan\theta = (\pm\frac{3}{1})$ or $(\pm\frac{1}{3})$ oe	
	First A1 for a correct relevant angle to nearest degree or better	
	Second A1 162^{o} (nearest degree is specified)	
1(b)	First M1 for use of **F** = *m***a** ; M0 if term missing or '2' missing or **a** = **0**	
	Second M1, independent but must have sum of at least two force = (*m*)**a**, for equating the **i** cpts, to produce a correct unsimplified equation in *p* and *q* **only,** for **their** vector equation. M0 if using **a** = **0**	
	Third M1, independent but must have at least two forces, for equating the **j** cpts to produce a correct unsimplified equation in *p* and *q* **only,** for **their** vector equation. M0 if using **a** = **0**	
	First A1 for *p* = -3	
	Second A1 for *q* = 2	

Question Number	Scheme	Marks
2.	$T + 4T = 60g + 30g$	M1 A1
	OR $M(P)$, $60g \times 2 + 30g \times 4 = 4T(4 - x)$	M1 A1 A1
	OR $M(Q)$, $4Tx + T \times 4 = 60g \times 2$	
	OR $M(R)$, $T(4 - x) + 30gx = 60g(2 - x)$	
	OR $M(G)$, $T \times 2 + 30g \times 2 = 4T(2 - x)$	
	$T = \frac{90g}{5}$ oe, 176 N or 180 N (Tension at P)	A1
	$x = \frac{2}{3}$ (0.67 or better)	A1
		(7)
	Notes	
	N.B. If T and $4T$ reversed consistently, treat as one error in any MOMENTS equations so could score max: M1A1M1A1A0A0A0	
2.	First M1 for resolving vertically or a moments equation, with all terms, condone sign errors and missing g's. M0 if a length is missing from a moments equation.	
	First A1 for a correct equation in one unknown	
	Second M1 for a(nother) moments equation, with all terms, condone sign errors and missing g(s)	
	Second and third A1's for a correct equation in two unknowns **Consistent** omission of g is one error. A1A0 for one error; A0A0 for two or more errors	
	Fourth A1 for any of the 3 answers.	
	Fifth A1 for 2/3 oe, 0.67 or better. **N.B.** This mark can be scored if they have consistently omitted g's. (T = 18)	

Question Number	Scheme	Marks
3(a)	$v = 5.25 \times 2.8 = 14.7$ $0 = 14.7 - 9.8t$ $T\,(= 5.25 + 1.5) = 6.75$ or 6.8	M1 A1 M1 A1 A1 (5)
(b)	 **N.B.** Graph could be reflected in the *t*-axis	B1 1st line B1 **ft** 2nd line with their **value** of *T* CLEARLY marked (2)
		(7)
	Notes	
3(a)	First M1 for a complete method to find the speed or velocity at $t = 5.25$ using $a = 2.8$	
	First A1 for 14.7 or – 14.7	
	Second M1 for a complete method to produce an (unsimplified) equation in **one unknown** (either their *t* or *T*) using their 14.7 and $v = 0$ Condone sign errors but need all terms	
	Second A1 for a correct equation. Allow if using $t = T$ (A0 if they use $g = 9.81$, but can score final A1)	
	Third A1 for $T = 6.75$ or 6.8 (as $g = 9.8$ used)	
3(b)	First B1 for a straight line starting at the origin	
	Second B1**ft** for another straight line starting at the end of their first line, with opposite gradient, which crosses the *t*-axis at 6.75 **OR ft** on their *T*. Penalise any extra lines including a solid vertical line at the end	

Question Number	Scheme	Marks
4(a)	Otherwise one particle would have to move through the other oe	B1 (1)
(b)	For P: $m\left(\frac{3u}{2}-(-v_P)\right)=\frac{7mu}{2}$ speed of $P=2u$	M1 A1 A1 (3)
(c)	For $Q: 4m(\frac{u}{8}-v_Q)=-\frac{7mu}{2}$ $v_Q=u$	M1 A1 A1 (3)
	OR	**OR**
	$4mv_Q-m2u=4m\frac{u}{8}+m\frac{3u}{2}$ $v_Q=u$	M1 A1 A1 (3)
		(7)
	Notes	
4(a)	B1 for a clear statement e.g if they are moving in the same direction, the one at the front must be going faster (than the one behind) or: the original momentum of P is less than the impulse exerted on P oe	
	N.B. For (b) and (c), they may find v_Q first and then use it to find v_P	
(b)	M1 for impulse-momentum principle applied to P ; condone sign errors but must be using m for mass and subtracting momenta M0 if g included	
	First A1 for a correct equation. They may have v_P instead of $-v_P$	
	Second A1 for $2u$; must be **positive**	
(c)	M1 for impulse-momentum principle applied to Q ; condone sign errors but must be using $4m$ for mass and subtracting momenta M0 if g included	
	First A1 for a correct equation. They may have $(-v_Q)$ instead of v_Q	
	OR	
	M1 for conservation of momentum, with correct no. of terms, condone sign errors, using their v_P or their v_Q . M0 if equation has more than one unknown	
	First A1 for a correct equation. They may have $(-v_Q)$ instead of v_Q	
	Second A1 for u ; must be **positive**	

Question Number	Scheme	Marks
	If F and R are interchanged, can score max: (a) M0A0M0A0M1M1A0 (b) M0A0M0A0	
5(a)	$T\sin\alpha = R$ $T\cos\alpha = 0.5g + F$ $F = \frac{1}{4}R$ Solving for T $T = \frac{5g}{4} = 1.25g = 12$ N or 12.3 N	M1 A1 M1 A1 M1 M1 A1 (7)
(b)	$T\cos\alpha = 0.5g - F$ $T\sin\alpha = R$ and $F = \frac{1}{4}R$ and solving for T $T = \frac{5g}{8} = 0.625g = 6.1$ N or 6.13 N	M1 A1 M1 A1 (4)
		(11)
	Notes	
5(a)	First M1 for resolving horizontally, with usual rules	
	First A1 for a correct equation	
	Second M1 for resolving vertically, with usual rules	
	Second A1 for a correct equation	
	Third M1 for use of $F = \frac{1}{4}R$	
	Fourth M1 for solving for T	
	Third A1 cao for any of the 4 alternatives	
5(b)	First M1 for resolving vertically, with usual rules **N.B**. M0 if using the value of R or F and/or T found in part (a)	
	First A1 for a correct equation	
	Second M1 for the other two equations, which must be correct, *and* solving for T **N.B**. M0 if using the value of R or F and/or T found in part (a)	
	Second A1 cao for any of the 4 alternatives	
	If the working for (b) is the same as for (a), they can score max M1A0M1A0	

Question Number	Scheme	Marks
6(a)	$(\text{i})\ \mathbf{r}_P = (\mathbf{i} + 4\mathbf{j}) + t(3\mathbf{i} - 2\mathbf{j})$ $(\text{ii})\ \mathbf{r}_Q = (7\mathbf{i} + 8\mathbf{j}) + t(5\mathbf{i} + 6\mathbf{j})$	M1 A1 A1 (3)
(b)	$\mathbf{QP} = (\mathbf{i} + 4\mathbf{j}) + t(3\mathbf{i} - 2\mathbf{j}) - \left[(7\mathbf{i} + 8\mathbf{j}) + t(5\mathbf{i} + 6\mathbf{j})\right]$ $= (-6 - 2t)\mathbf{i} + (-4 - 8t)\mathbf{j}$ Given Answer	M1 A1 (2)
(c)	$(-6 - 2t) = (-4 - 8t)$ $t = \frac{1}{3}$ $\mathbf{QP} = (-6 - \frac{2}{3})\mathbf{i} + (-4 - \frac{8}{3})\mathbf{j}$ $QP = \sqrt{\left(-\frac{20}{3}\right)^2 + \left(-\frac{20}{3}\right)^2}$ $= \frac{20\sqrt{2}}{3} = 9.4$ km (or better)	M1 A1 M1 M1 A1 (5)
		(10)
	Notes	
	Allow column vectors throughout apart from the given answer in (b)	
6(a)	M1 for attempt at either or $\mathbf{r}_Q$ with the correct structure oe	
	First A1 for a correct expression for $\mathbf{r}_P$ in any form	
	Second A1 for a correct expression for $\mathbf{r}_Q$ in any form	
(b)	M1 for their $\mathbf{r}_P$ – their $\mathbf{r}_Q$ in any form	
	A1 for **given answer Must be in i – j form**	
(c)	First M1 for using SW to produce an equation in *t* only. M0 if they use the ratio **i** cpt: **j** cpt = -1	
	First A1 for $t = 1/3$ cao	
	Second M1 for substituting their *t* into **QP** but can only be scored if *t* has come from using ratio **i** cpt: **j** cpt = 1 or -1 **N.B.** M0 if *t* is negative or if they have more than one value of *t*.	
	Third M1 for finding the magnitude of their **QP** (even if $t < 0$), but must have found a value for *t* and substituted it in to give a **QP** with numerical cpts.	
	Second A1 for surd answer, in any form, or 9.4 (km) or better	

Question Number	Scheme	Marks
7(a)	$0 = u - 0.5\times 5$ $u = 2.5$ (m s^{-1}) Given answer	M1 A1 (2)
(b)	$0 = 2.5^2 - 2\times 5s$ $s = 0.625$ (m) or oe **OR** e.g. $s = \frac{(0+2.5)}{2}\times 0.5 = 0.625$ (m)	M1 A1 (2)
(c)	64.8 km h^{-1} = 18 m s^{-1} $0 = 18 - 5t$ **OR** $2.5 = 18 - 5t$ $t = 3.6$ **OR** $t = 3.1$ **Any of:-** e.g. $18\times(4.2-t)$ **OR** $18\times(4.2-0.5-t)$ $s = \frac{1}{2}(18+2.5)\times 3.1$ $s = (18\times 3.1 + \frac{1}{2}\times -5\times 3.1^2)$ $s = (2.5\times 3.1 - \frac{1}{2}\times -5\times 3.1^2)$ $2.5^2 = 18^2 + 2\times(-5)s$ 10.8 31.775 m Total distance = (10.8 + 31.775) = 42.575 (m)	B1 M1 A1**ft** on their 18 M1 A1**ft** on t &18 A1 cao A1 cao (7)
		(11)
	Notes	
7(a)	M1 for a complete method to obtain an equation in u only and must see $v = 0$ and $a = -5$ used. **N.B**. M0A0 for 5 x 0.5 = 2.5	
	A1 for 2.5 (ms^{-1}) correctly obtained	
7(b)	M1 for a complete method to obtain an equation in s only	
	A1 for 0.625 (m)	
7(c)	B1 for 18 (ms^{-1}) **N.B.** If no attempt to change units, only M marks available	
	First M1 for finding the time t to decelerate from their 18 to rest **OR** from 18 to S	
	First A1 **ft** on their 18 and one of their t values found	
	Second M1 for an attempt at finding	

	EITHER the distance travelled at their constant speed using a **calculated** value of **OR** the distance travelled while decelerating until car passes *S*	
	Second A1 **ft** for distance travelled at constant speed, ft on their 18 and *t* value	
	Third A1 cao 31.775 (m) (can be unsimplified)	
	Fourth A1 for 42.575 (m) cao	

Question Number	Scheme	Marks
8(a)	$3mg - T = 3ma$ $T - mg = ma$	M1 A1 M1 A1 (4)
(b)	$3mg - mg = 4ma$ $a = 0.5g$ Given answer	**DM**1 A1 (2)
(c)	The magnitude of the acceleration for both particles is the same	B1 (1)
(d)	$V = \sqrt{2 \times 0.5gh} = \sqrt{gh}$	M1 A1 (2)
(e)	$I = 3m(\frac{1}{2}V - -V)$ $= \frac{9m\sqrt{gh}}{2}$	M1 A1 A1 (3)
(f)	$0 = (\frac{1}{2}V)^2 - 2gd$ $d = \frac{h}{8}$	M1 A1 (2)
		(14)
	Notes	
8(a)	First M1 for an equation of motion for *A* with usual rules	
	First A1 for a correct equation. Allow *a* replaced by (-*a*) in both equations	
	Second M1 for an equation of motion for *B* with usual rules	
	Second A1 for a correct equation. Allow *a* replaced by (-*a*) in both equations	
(b)	**DM**1 for producing an equation in *a* only, dependent on two M marks in (a), must show elimination of T i.e. at least one line of working e.g. $2mg = 4ma$	
	A1 for $a = 0.5g$ with given answer correctly obtained (A0 for $\frac{1}{2}g$) **N.B.** M0 for the whole system equation Allow *a* replaced by (-*a*) but to get final A1 must state (magnitude) acceleration is $0.5g$	
(c)	B1 Clear statement. E.g. They have the same acceleration – allow omission of 'magnitude'. Penalise incorrect extras.	
(d)	M1 for a complete method to give an equation in *V*, *g* and *h* only, using $a = \frac{1}{2}g$	
	A1 for $V = \sqrt{gh}$ oe	
(e)	M1 for use of impulse-momentum with $3m$ (M0 if using *m* or no mass or extra *g*), condone sign errors, but must be subtracting momenta	
	First A1 for $\pm 3m(\frac{1}{2}V - -V)$ with their *V*; can be in terms of *V* only or a mix of *V*, *g* and *h*	
	Second A1 for $\frac{9m\sqrt{gh}}{2}$ oe; Must be positive.	
(f)	M1 for a complete method to give an equation in *V*, *g* and *d* only with $a = \pm g$ and $v = 0$ and $u = \frac{1}{2}V$ or $v = \frac{1}{2}V$ and $u = 0$ Must be a dimensionally correct equation.	
	A1 for $\frac{h}{8}$ or $0.125h$	

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