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Mark Scheme (Results)

Summer 2017

Pearson Edexcel GCE
In 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)

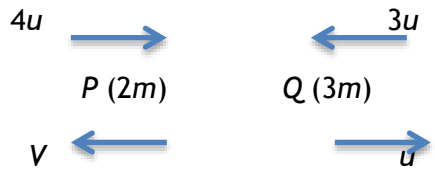
  HL Hooke's Law

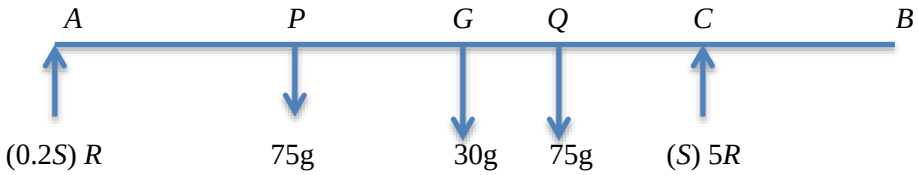
  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1	$(15\mathbf{i} + \mathbf{j}) + (5q\mathbf{i} - p\mathbf{j}) + (-3p\mathbf{i} - q\mathbf{j}) = \mathbf{0}$ $3p - 5q = 15$ $p + q = 1$ $p = 2.5 \quad q = -1.5$	M1 M1 A1 M1 A1 A1 **6**
	Notes	
	First M1 for equating the sum of the three forces to zero (can be implied by subsequent working) Second M1 for equating the sum of the **i** components to zero AND the sum of the **j** components to zero oe to produce TWO equations, each one being in p and q ONLY. First A1 for TWO correct equations (in any form) **N.B.** It is possible to obtain TWO equations by using $\lambda(3p - 5q - 15) = \mu(p + q - 1)$ with TWO different pairs of values for λ and μ, with one pair not a multiple of the other e.g $\lambda = 1$, $\mu = 1$ AND $\lambda = 1$, $\mu = 2$. Third M1(independent) for attempt (either by substitution or elimination) to produce an equation in either p ONLY or q ONLY. Second A1 for $p = 2.5$ (any equivalent form, fractions do not need to be in lowest terms) Third A1 for $q = -1.5$ (any equivalent form, fractions do not need to be in lowest terms)	

Question Number	Scheme	Marks
2(a)	 $8mu - 9mu = -2mV + 3mu$ $V = 2u$	M1 A1 A1 (3)
(b)	(Has been) reversed	B1 (1)
(c)	For Q: $I = 3m(u - -3u)$ $= 12mu$ OR: For P: $I = 2m(2u - -4u)$ $= 12mu$	M1 A1 A1 (3) **OR** M1 A1 A1 (3) **7**
	Notes	
(a)	M1 for CLM with correct no. of terms, all dimensionally correct, to give an equation in m, u and their V only. Condone consistent g's or cancelled m's. First A1 for a correct equation (they may have + $2mV$) Second A1 for $2u$ (must be positive since speed is required)	
(b)	B1 for '(has been) reversed'. Only available if a correct velocity has been correctly obtained in part (a). B0 for 'changed' ,'direction has changed' , 'yes'	
(c)	M1 for using Impulse = change in momentum of Q (must have $3m$ in both terms) (M0 if *clearly* adding momenta or if g is included) but condone sign errors. First A1 for $3m(u - -3u)$ or $-3m(u - -3u)$ Second A1 for $12mu$ (must be positive since magnitude required) **OR** M1 for using Impulse = change in momentum of P (must have $2m$ in both terms) (M0 if *clearly* adding momenta) but condone sign errors. First A1 for $2m(2u - -4u)$ or $-2m(2u - -4u)$ Second A1 for $12mu$ (must be positive since magnitude required) N.B. Allow use of $I = 3m(u - v)$ or $I = 2m(u - v)$ since only magnitude required	

Question Number	Scheme	Marks
3(a)	 (-) $R+5R=75g+30g+75g$ $M(A)$ $75gx+75g2x+30g \times 3=5R \times 4$ $x=\frac{34}{15}=2.3$ or better (N.B. Or another Moments Equation)	M1 A2 M1 A2 A1 **(**M1 A2) (7)
(b)	uniform – mass is or acts at midpoint of plank; centre of mass is at middle of plank; weight acts at the middle of the plank, centre of gravity is at midpoint rod - plank does not bend, remains straight, is inflexible, is rigid	B1 B1 (2) **9**
	Notes	
(a)	First M1 for either a vertical resolution (with correct of terms) or a moments equation (all terms dim correct and correct no. of terms) First A1 and Second A1 for a correct equation in R (or S where $S = 5R$) only or R and x only or S and x only. (- 1 each error , A1A0 or A0A0) Second M1 for a moments equation (all terms dim correct and correct no. of terms) Third A1 and Fourth A1 for a correct equation in R (or S where $S = 5R$) only or R and x only or S and x only. (- 1 each error, A1A0 or A0A0) Fifth A1 for $x = {}^{34}/_{15}$ oe or 2.3 (or better) **(i)** In a moments equation, if R and $5R$ (or S and $0.2S$) are interchanged, treat as 1 error. **(ii)** Ignore diagram if it helps the candidate. **(iii)** If an equation is correct but contains both R and S, *or $S = 5R$ is never used*, treat as 1 error. **(iv)** Full marks possible if all g's omitted. **(v)** For inconsistent omission of g, penalise each omission. $M(B), R' 6+5R' 2=75g(6-x)+75g(6-2x)+30g' 3$ $M(C), 75g(4-x)+75g(4-2x)+30g' 1=R' 4$ $M(G), 75g(3-x)+5R' 1=R' 3+75g(2x-3)$ $M(P), Rx+30g(3-x)+75gx=5R(4-x)$ $M(Q), 75gx+30g(2x-3)+5R(4-2x)=R' 2x$	
(b)	First B1 for first correct answer seen. Second B1 for the other answer, but only award this second mark if no extras given.	

Question Number	Scheme	Marks
4	$F = \mu R$ ($\nwarrow$), $R = 10\sin\alpha + 5g\cos\alpha$ (45.2) ($\nearrow$), $F = 5g\sin\alpha - 10\cos\alpha$ (21.4) $\mu = \dfrac{g\sin\alpha - 2\cos\alpha}{2\sin\alpha + g\cos\alpha} = 0.47$ or 0.473	B1 M1 A2 M1 A2 M1 A1 **9**
	Notes	
	B1 for $F = \mu R$ seen or implied First M1 for resolving perpendicular to the plane with usual rules First and second A1's for a correct equation. A1A0 if one error. Second M1 for resolving parallel to the plane with usual rules Third and fourth A1's for a correct equation. A1A0 if one error. If m is used instead of 5, penalise once in each equation. Third M1 <u>independent</u> for eliminating R to produce an equation in μ only. Does not need to be $\mu =$ …. Fifth A1 for 0.47 or 0.473.	

Question Number	Scheme	Marks
5	$T - 0.5g = 0.5a$ $15 - T - 0.75g = 0.75a$ (OR: $15 - 0.5g - 0.75g = 1.25a$) $(a = 2.2 \text{ m s}^{-2})$ $T = 6$ N	M1 A1 M1 A1 M1 A1 **6**
	Notes	
	First M1 for an equation of motion for either *P* or *Q* with usual rules i.e. correct no. of terms, dimensionally correct but condone sign errors First A1 for a correct equation (allow *T* replaced by – *T* and/or *a* replaced by –*a*) Second M1 for another equation of motion (for either *P* or *Q* or whole system) with usual rules as above Second A1 for a correct equation (allow *T* consistently replaced by – *T* and/or *a* consistently replaced by –*a*) Third M1 for solving two THREE term equations of **motion** for *T* Third A1 for 6 (N). Must be positive but allow a change from – 6 to 6, if they have consistently used -*T* instead of *T*.	

Question Number	Scheme	Marks
6(a)	$s = vt - \frac{1}{2}at^2$ $40 = 10 \times 5 - \frac{1}{2}a5^2$ $a = 0.8$	M1 A2 A1 (4)
(b)	Finding u (= 6) $s = ut + \frac{1}{2}at^2$ (A to M) $20 = 6t + \frac{1}{2}0.8t^2$ $t = \frac{-15 \pm \sqrt{225 + 200}}{2}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM**1 A1 (5)
	Alternative : Finding v (= $\sqrt{68}$) $s = vt - \frac{1}{2}at^2$ (A to M) $20 = \sqrt{68}t - \frac{1}{2}0.8t^2$ $t = \frac{\sqrt{68} \pm \sqrt{68 - 32}}{0.8}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM1** A1 (5)
	Alternative : $s = vt_1 - \frac{1}{2}at_1^2$ (M to B) $20 = 10t_1 - \frac{1}{2}0.8t_1^2$ $t_1 = \frac{10 \pm \sqrt{100 - 32}}{0.8}$ $= 2.192$ $t = 5 - t_1 = 2.8$ or 2.81 or better	M2 A1 **DM**1 A1 (5) **9**

	Notes	
6(a)	First M1 for a complete method to produce a value for *a*. They may use two (or more equations) and solve for *a*.(see possible equations) A2 if all correct, A1A0 for one error Third A1 for 0.8 (m s^{-2}) Possible equations: $40 = 5u + \frac{1}{2}a.5^2$ $10^2 = u^2 + 2a.40$ $10 = u + 5a$ $40 = \frac{(u+10)}{2}.5$	
6(b)	First M1 for attempt to find a value for u (This may have been done in part (a) but MUST be used in (b)) Second M1 for a complete method (may involve 2 or more *suvat* equations) for finding an equation in *t only* First A1 for a correct equation Third M1, **dependent** on previous M, for solving their equation for *t* Second A1 for 2.8 (s) or better or $\frac{5(2\sqrt{17} - 6)}{4}$; $\frac{40}{6+2\sqrt{17}}$	

Question Number	Scheme	Marks
7(a)	$\tan q = \frac{2}{9}$ $q = 12.5^o$ bearing 103^o	M1 A1 A1 (3)
(b) **(i)** **(ii)**	$\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$ $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$	M1 A1 A1 (3)
(c)	$\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$	M1 A1 (2)
(d)	$D^2 = (8 + 5t)^2 + (6 - 10t)^2$ $= 125t^2 - 40t + 100$ $100 = 125t^2 - 40t + 100$ $0 = 5t(25t - 8)$ $t = 0$ or 0.32	M1 A1 M1 M1 A1 A1 (6) **14**
	Notes	
7(a)	M1 for $\tan q = \pm\frac{2}{9}$ or $\pm\frac{9}{2}$ or use $\sin q$ or $\cos q$	
	First A1 for $q = \pm 13^o$ or $\pm 77^o$ or $\pm 12.5^o$ or $\pm 77.5^o$ or better	
	Second A1 for 103^o	
7(b)	M1 for clear attempt at $\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$ or $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$ (Allow slips but must be a '+' sign and **r** + *t* **v)**	
(i)	First A1 for $\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$oe	
(ii)	Second A1 for $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$oe	
7(c)	M1 for **p** – **q** or **q** – **p** with their **p** and **q** substituted A1 for correct answer $\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$ (don't need $\overrightarrow{QP}$ but on R.H.S must be **identical** coefficients of **i** and **j** but allow column vectors)	
7(d)	First M1 for attempt to find QP or QP^2 in terms of *t only*, using correct formula First A1 for a correct expression (with or without √) $125t^2 - 40t + 100$ Second M1 for √ (3 term quadratic) = 10 or (3 term quadratic) =100. Third M1 for quadratic expression = 0 and attempt to solve (e.g. factorising or using formula) Second A1 for $t = 0$ (if they divide by *t* and lose this value but get 0.32, M1A0A1) Third A1 for $t = 0.32$ oe	

Question Number	Scheme	Marks
8(a) **(i)** **(ii)**	For A : $T - F = 2ma$ For B : $mg - T = ma$	M1 A1 M1 A1 (4)
(b)	$R = 2mg$ $mg(1-2\mu) = 3ma$ $\frac{g}{3}(1-2\mu) = a$	B1 M1 A1 (3)
(c)	$v^2 = \frac{2gh}{3}(1-2\mu)$ $v = \sqrt{\frac{2gh}{3}(1-2\mu)}$	M1 A1 (2)
(d)	$-\mu R = 2ma$ ¢ $0^2 =$ their $u^2 - 2as$ ¢ $0 = \frac{2gh}{3}(1-\frac{2}{3}) - 2(\frac{1}{3}g)s$ (or $s = (d-h)$) $s = \frac{1}{3}h$ $d = \frac{1}{3}h + h = \frac{4}{3}h$	M1 M1 A1 (A1) A1 A1 (5)
(e)	A (or B) would not move; **OR** A (or B) would remain in (limiting) equilibrium; **OR** the system would remain in (limiting) equilibrium	B1 (1) **15**

	Notes	
8(a)(i) **(ii)**	First M1 for equation of motion for A with usual rules First A1 for a correct equation (allow $-T$ instead of T) Second M1 for equation of motion for B with usual rules Second A1 for a correct equation (allow consistent $-T$ instead of T)	
8(b)	B1 for $R = 2mg$ M1 for using $F = \mu R$ and eliminating to give equation in a and μ only. A1 for PRINTED ANSWER (Must be identical to printed answer)	
8(c)	M1 for using $v^2 = u^2 + 2as$ or any other complete method to find the speed of A A1 for correct answer in any form	
8(d)	First M1 for equation of motion for A with $T = 0$ and $F = \mu R$ e.g. $\mu R = 2ma$ (must be $2m$) Second M1 for using $v^2 = u^2 + 2as$ with their u^2 from (c), $v = 0$ and a **new** a (does **not** need to be substituted) First A1 for a correct equation in s, g and h with $\mu = {}^1/_3$ Second A1 for $s = {}^1/_3\, h$ Third A1 for $d = {}^4/_3\, h$ **ALTERNATIVE** using work-energy principle: M2 for $\mu Rs = \frac{1}{2}2mu^2$ (their u^2 from (c)) (M1 if they use m) First A1 for $\frac{1}{3}2mgs = \frac{1}{2}2m\frac{2gh}{3}(1 - \frac{2}{3})$ Second A1 for $s = {}^1/_3\, h$ Third A1 for $d = {}^4/_3\, h$	
8(e)	B1 for any one of the alternatives listed above.	

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