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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Mechanics 1R (6677_01R)

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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. 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.

6. 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)	Resolving horizontally: $5 = T\cos 65°$ $T =$ 12, 11.8, or better (N)	M1A1 A1 (3)
(b)	Resolving vertically: $W = T\cos 25°$ $= 11.8\cos 25° =$ 11, 10.7 or better (N)	M1A1 A1 (3)
		[6]

Notes for Question 1

Question 1(a)

First M1 for resolving horizontally with correct no. of terms and T term resolved.
First A1 for a correct equation in T only.
Second A1 for 12 (N) or 11.8 (N) or better.
N.B. The M1 is for a *complete method* to find the tension so where two resolution equations, neither horizontal, are used, the usual criteria for an M mark must be applied to *both* equations and the first A1 is for a correct equation in T *only* (i.e. W eliminated correctly)

Alternatives:

Lami's Theorem: $\frac{T}{\sin 90^o} = \frac{5}{\sin 155^o}$ (same equation as → resolution) M1A1

Question 1(b)

First M1 for resolving vertically with correct no. of terms and T (does not need to be substituted) term resolved.
First A1 for a correct equation in T only.
Second A1 for 11 (N), 10.7 (N) or better.

Alternatives:

Triangle of forces: $W = 5\tan 65^o$ M1A1

Lami's Theorem: $\frac{T}{\sin 90^o} = \frac{W}{\sin 115^o}$ M1A1

Or Resolution in another direction e.g. along the string M1 (usual criteria) A1 for a correct equation.

Question Number	Scheme	Marks
2(a)	$(4\mathbf{i} - 2\mathbf{j}) + (2\mathbf{i} + q\mathbf{j}) = (6\mathbf{i} + (q-2)\mathbf{j})$ $6 = 2(q-2)$ ratio 2:1 $q = 5$	M1A1 **DM**1 A1 (4)
(b)	$6\mathbf{i} + 3\mathbf{j} = 1.5\mathbf{a}$ $\mathbf{a} = (4\mathbf{i} + 2\mathbf{j})$ m s^{-2} $\mathbf{v} = \mathbf{u} + \mathbf{a}t = (-2\mathbf{i} + 4\mathbf{j}) + 2(4\mathbf{i} + 2\mathbf{j})$ $= 6\mathbf{i} + 8\mathbf{j}$ speed $= \sqrt{6^2 + 8^2}$ $= 10$ m s^{-1}	M1 A1 M1 A1**ft** **M**1 A1 (6) **[10]**

Notes for Question 2

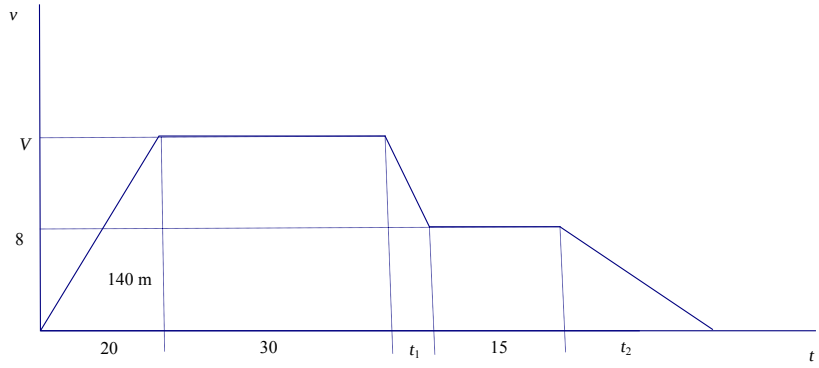
Question 2(a)

First M1 for $(4\mathbf{i} - 2\mathbf{j}) + (2\mathbf{i} + q\mathbf{j})$
First A1 for $(6\mathbf{i} + (q-2)\mathbf{j})$ (seen or implied)
Second M1, **dependent on first M1**, for using 'parallel to $(2\mathbf{i} + \mathbf{j})$' to obtain an equation in *q only*.
Second A1 for $q = 5$

Question 2(b)

First M1 for their **resultant force** $= 1.5\mathbf{a}$
First A1 for $\mathbf{a} = 4\mathbf{i} + 2\mathbf{j}$
Second M1 for $(-2\mathbf{i} + 4\mathbf{j}) + 2$ x (their **a)** **(M0** if force is used instead of **a)**
Second A1 **ft** for their velocity at $t = 2$
Third M1for finding the magnitude of their velocity at $t = 2$
Third A1 for 10 (ms^{-1})

N.B. In (b), if they use scalars throughout, M0A0M0A0M0A0

Question Number	Scheme	Marks
3(a)		B1 $0 < t < 50$ B1 $50 < t$ B1 (V,8,15, 20,30) (3)
(b)	Use area under graph or *suvat* to form an equation in V only. $140 = \frac{1}{2} \times 20 \times V$ $V = 14$	M1 A1 (2)
(c)	$8 = V - \frac{1}{2}t_1$ (and /or $0 = 8 - \frac{1}{3}t_2$) $t_1 = 12$, (and/or $t_2 = 24$) Total time = $20 + 30 + t_1 + 15 + t_2 = 101$ (seconds)	M1 A1 **DM**1 A1 (4)
(d)	Total distance = $140 + 30V + \frac{V+8}{2}t_1 + 15 \times 8 + \frac{1}{2} \times 8 \times t_2$ $= 140 + 30 \times 14 + 11 \times 12 + 15 \times 8 + 24 \times 4$ =908 (m)	M1A2 **ft** A1 (4)
		[13]

Notes for Question 3

Question 3(a)

First B1 for shape of graph for $0 \leq t \leq 50$
Second B1 for shape of graph for $t > 50$
Third B1 for V, 8, 15, 20, 30 appropriately used

Question 3(b)

M1 for use of area under graph (must have '1/2') or *suvat* to obtain an equation in V only.
A1 for $V = 14$

Question 3(c)

First M1 for use of either $8 = V - ½\, t_1$ or $0 = 8 - {}^1/_3\, t_2$
First A1 for either $t_1 = 12$ or $t_2 = 24$
Second M1, **dependent on the first M1**, for $20 + 30 + t_1 + 15 + t_2$ (must include all 5 times)
Second A1 for 101 (s)

Question 3(d)

First M1 for an expression for the total area (distance) **including all parts of the motion**. Where a triangle or trapezium is used , a '1/2' must be seen.
Second A2 **ft** on their V, t_1 and t_2 , -1 each error.
Fourth A1 for 908 (m).

Question Number	Scheme	Marks
4(a)	Max ht $v = 0$. $v = u - gt \Rightarrow T = \dfrac{u}{g}$	M1A1 (2)
(b)	Max ht $H = ut + \dfrac{1}{2}at^2 = \dfrac{u^2}{g} - \dfrac{u^2}{2g} = \dfrac{u^2}{2g}$ * Given answer* Or use of $v^2 = u^2 + 2as$	M1A1 (2)
(c)	$-3 \times \dfrac{u^2}{2g} = ut - \dfrac{1}{2}gt^2$ $-3u^2 = 2ugt - g^2t^2$ $g^2t^2 - 2ugt - 3u^2 = 0, \quad gt = \dfrac{2u \pm \sqrt{4u^2 + 12u^2}}{2}$ $t = \dfrac{3u}{g} = 3T$	M1 **DM**1 A1 A1 (4)
(c) alt	$-4H = -\dfrac{1}{2}gt^2$ Total time = $T + \sqrt{\dfrac{8H}{g}} = T + \sqrt{\dfrac{8u^2}{2g^2}}$ $= T + 2T = 3T$	M1 **DM**1A1 A1 (4)
		[8]

Notes for Question 4

Question 4

In this question, condone sign errors in a *suvat* equation for the M mark, but a missing term is M0 or an incorrect term is M0. An incorrect *suvat* formula is M0

Allow use of symmetry of motion.

e.g. in (a), using *v = u + at, either 0 = u – gT or u = 0 +gT*

Question 4(a)

M1 for use of *suvat* to obtain an equation in *T*, *u* and *g* only.

A1 for $T = u/g$ correctly obtained.

Question 4(b)

M1 for use of *suvat* to obtain an equation in *H*, *u* and *g* only.

A1 for $H = u^2/2g$ correctly obtained **(given answer)**

Question 4(c) *Watch out for t / T confusion* (**N.B**. if only *T*'s used, M0DM0)

First M1 for a complete method to find the *total* time in terms of *u*, *g*, *H* or *T*:-

either: $3H = -ut + \frac{1}{2} gt^2$

or: $4H = \frac{1}{2} gt^2$ and $t + T$

or: $v^2 = u^2 + 6gH$ and $v = -u + gt$,with *v* eliminated

Second M1, **dependent on first M1**, for producing an expression, in terms of *u*, *g*, *H* or *T,* for the total time, by solving a quadratic

First A1 for any correct expression for the total time in terms of *u*, *g*, *H* or *T*.

Second A1 for 3*T* cso

Question Number	Scheme	Marks
5a	$3mg - T = 3ma$ $T - 2mg = 2ma$ $T = 2mg + 2\left(mg - \frac{T}{3}\right)$ $T = \frac{12}{5}mg$ ***Given Answer***	M1A1 M1A1 **DM**1 A1 (6)
b	$a = \frac{g}{5}$ At time of impact $v^2 = u^2 + 2as = 2 \times \frac{g}{5} \times 1.5 = 0.6g$ Vertical motion under gravity $0 = 0.6g - 2gs$ $s = 0.3\,(\text{m})$ Total distance $2 \times 0.3 = 0.6$ (m)	B1 M1A1 M1 **DM**1A1 (6)
c	Impulse = $3m(v-u) = -3mu$ Magnitude = $3m\sqrt{0.6g} = 3.6$ (Ns) (3.64)	M1 A1 (2) **[14]**

Notes for Question 5

Question 5(a)

First M1 for resolving vertically (up or down) for *B,* with correct no. of terms etc (allow if they omit *m* but have the 3)
First A1 for a correct equation.
Second M1 for resolving vertically (up or down) for *A,* with correct no. of terms etc (allow if they omit *m* but have the 2)
Second A1 for a correct equation
Third M1, **dependent on the first two M marks**, for eliminating *a*
Third A1 for $T = 12mg/5$ **given answer**

N.B. Either equation above can be replaced by the whole system equation
M1A1 for $3mg - 2mg = 5ma$; any error loses both marks.

N.B. If *m* has been omitted in (a), which has led to a dimensionally incorrect value of *a*, can score max B0M1A0M1M1A0 in (b) and M1A0 in (c).

Question 5(b)

B1 for $a = g/5$ found (possibly in part (a)) and used here.
First M1 for using *suvat* with their *a* from part (a), to find the speed *v* (or v^2) of *B* at impact
First A1 for $\sqrt{(0.6g)}$ oe, 2.4 or better (may be implied) *found correctly.*
Second M1 for using *suvat* with $a = \pm g$, to obtain an equation in *s* only, using their *v* (or v^2) *with final velocity* = 0
Third M1, **dependent on second M1**, for doubling their *s* value
Second A1 for 0.6 (m)

Question 5(c)

M1 for $\pm 3m$ x (their *v*) or ± 1.5 x (their *v*) or
$\pm m$ x (their *v*) or ± 0.5 x (their *v*)
M0 if $3m$ missing or extra *g*
A1 for 3.6 or 3.64 (Ns)

Question Number	Scheme	Marks
6a	Resolving vertically: $T + 2T\left(= 3T\right) = W$ Moments about B: $2 \times 2T = \left(d - 1\right)W$ Substitute and solve for d : $2 \times 2T = \left(d - 1\right)3T$ $d = \frac{7}{3}$ (m)	M1A1 M1A1 **D**M1 A1 (6)
6b	Moments about C: $(T_B \times 2) + (kW \times 1) = W \times \frac{2}{3}$ $T_B = W\frac{\left(2 - 3k\right)}{6}$ or equivalent	M1A1 A1 (3)
6c	solving $T_B \geq 0$ or $T_B > 0$ for k. $0 < k \leq 2/3$ or $0 < k < 2/3$ only	M1 A1 (2)
		[11]

Notes for Question 6

Question 6(a)

N.B. If Wg is used, mark as a misread.

First M1 for an equation in W and T and possibly d (either resolve vertically or moments about any point other than the centre of mass of the rod), with usual rules.

First A1 for a correct equation.

Second M1 for an equation in W and T and possibly d (either resolve vertically or moments about any point other than the centre of mass of the rod), with usual rules.

Second A1 for a correct equation.

N.B. The above 4 marks can be scored if their d is measured from a different point

Third M1, dependent on first and second M marks, for solving for d

Third A1 for $d = 7/3$, 2.3 (m) or better

N.B. Alternative

If a single equation is used (see below) by taking moments about the centre of mass of the rod, $2T(3 - d) = T(d - 1)$, this scores M2A2 (-1 each error)

Third M1, dependent on first and second M marks, for solving for d

Third A1 for $d = 7/3$

Question 6(b)

First M1 for producing an equation in T_B and W *only*, either by taking moments about C, or using two equations and eliminating

First A1 for a correct equation

Second A1 for $W(2 - 3k)/6$ oe.

N.B. **M0** if they use any information about the tension(s) from part (a).

Question 6(c)

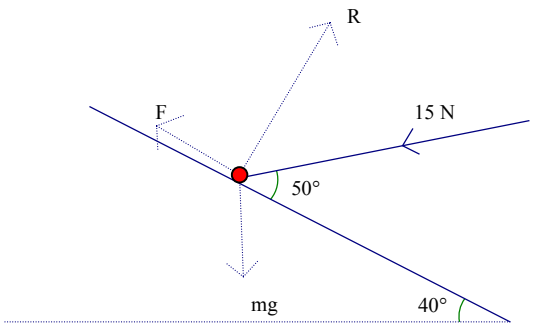
M1 for solving $T_B \geq 0$ or $T_B > 0$ for k.

A1 for $0 < k \leq 2/3$ or $0 < k < 2/3$ only.

N.B.

$T = 0 \Rightarrow k = 2/3$ then answer is M0.

If they also solve $T_C \geq 0$ or $T_C > 0$, can still score M1 and possibly A1.

Question Number	Scheme	Marks
7a	 Perpendicular to the slope: $R = 2.7g\cos 40 + 15\cos 40$ $= 31.8$ (N) or 32 (N)	M1A2 A1 (4)
7b	Parallel to the slope: $F = 2.7g\sin 40 - 15\cos 50 \quad (F = 7.366..)$ Use of $F = \mu R$ $\mu = \dfrac{2.7g\sin 40 - 15\cos 50}{R} = 0.23$ or 0.232	M1A2 M1 A1 (5)
7c	Component of wt parallel to slope = $2.7g\sin 40° \ (= 17.0)$ $F_{max} = 0.232 \times 2.7 \times g \times \cos 40° = 4.7...$ (N) $17.0 > 4.70$ so the particle moves	B1 M1A1 A1 (4)
		[13]

Notes for Question 7

N.B. Only penalise over- or under-accuracy after using $g = 9.8$, (or use of g = 9.81), once in whole question**.**

Question 7(a)

First M1 for resolving perpendicular to the slope, with correct no. of terms, and both the 2.7g and 15 terms resolved.
First A2 for a correct equation; -1 each error.
Third A1 for 32 (N) or 31.8 (N)

Question 7(b)

First M1 for resolving parallel to the slope, with correct no. of terms, and both the 2.7g and 15 terms resolved.
First A2 for a correct equation; -1 each error.
Second M1 for use of $F = \mu R$
Third A1 for 0.23 or 0.232

Question 7(c)

B1 for component of weight down the plane $2.7g\sin 40^o$ (17 or better)
M1 for using their **NEW *R*** and μ to find max friction (M0 if they use *R* from (a))
First A1 for 4.7(or better) (should be 4.701242531)
Second A1 for comparison and correct conclusion.
N.B. If first A mark is 0, the second A mark must also be 0.

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