Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6677/01R	Signature	

Paper Reference(s)

6677/01R

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Friday 6 June 2014 – Afternoon

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
Total	

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	Nil

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation or symbolic differentiation/integration, or have retrievable mathematical formulae stored in them.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initials and signature.
Check that you have the correct question paper.
Answer ALL the questions.
You must write your answer to each question in the space following the question.
Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$ and give your answer to either two significant figures or three significant figures.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 7 questions in this question paper. The total mark for this paper is 75.
There are 28 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You should show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

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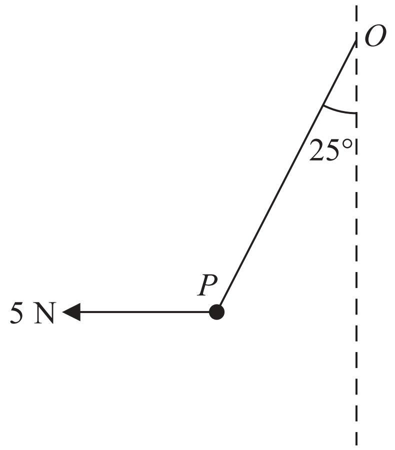

Figure 1

A particle P of weight W newtons is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point O. A horizontal force of magnitude 5 N is applied to P. The particle P is in equilibrium with the string taut and with OP making an angle of 25° to the downward vertical, as shown in Figure 1.

Find

(a) the tension in the string,
(3)

(b) the value of W.
(3)

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: $\frac{T}{\sin 90°} = \frac{5}{\sin 155°}$ (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: $W = 5\tan 65°$ M1A1

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

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

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2. Two forces $(4\mathbf{i} - 2\mathbf{j})$ N and $(2\mathbf{i} + q\mathbf{j})$ N act on a particle P of mass 1.5 kg. The resultant of these two forces is parallel to the vector $(2\mathbf{i} + \mathbf{j})$.

(a) Find the value of q.

(4)

At time $t = 0$, P is moving with velocity $(-2\mathbf{i} + 4\mathbf{j})\,\text{m s}^{-1}$.

(b) Find the speed of P at time $t = 2$ seconds.

(6)

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

<u>Question 2(a)</u>

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 $q = 5$

<u>Question 2(b)</u>

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 M1 for finding the magnitude of <u>their velocity at $t = 2$</u>

Third A1 for 10 (ms^{-1})

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

Leave blank

3. A car starts from rest and moves with constant acceleration along a straight horizontal road. The car reaches a speed of V m s^{-1} in 20 seconds. It moves at constant speed V m s^{-1} for the next 30 seconds, then moves with constant deceleration $\frac{1}{2}$ m s^{-2} until it has speed 8 m s^{-1}. It moves at speed 8 m s^{-1} for the next 15 seconds and then moves with constant deceleration $\frac{1}{3}$ m s^{-2} until it comes to rest.

(a) Sketch, in the space below, a speed-time graph for this journey.

(3)

In the first 20 seconds of this journey the car travels 140 m.

Find

(b) the value of V,

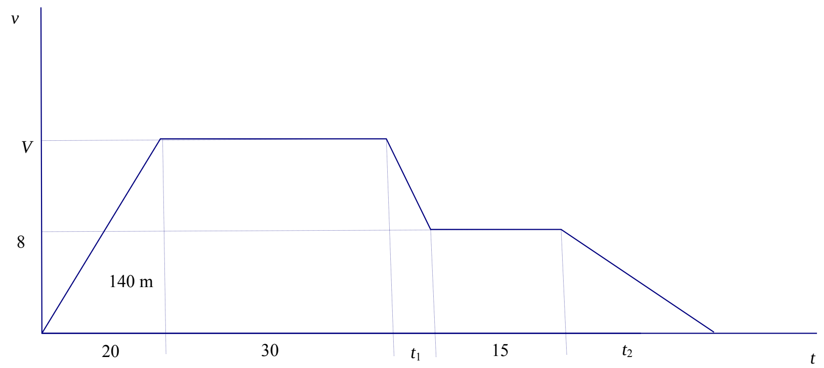
(2)

(c) the total time for this journey,

(4)

(d) the total distance travelled by the car.

(4)

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 $0 \le t \le 50$
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).

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4. At time $t = 0$, a particle is projected vertically upwards with speed u from a point A. The particle moves freely under gravity. At time T the particle is at its maximum height H above A.

(a) Find T in terms of u and g.

(2)

(b) Show that $H = \dfrac{u^2}{2g}$

(2)

The point A is at a height $3H$ above the ground.

(c) Find, in terms of T, the total time from the instant of projection to the instant when the particle hits the ground.

(4)

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: $3H = -ut + ½ gt^2$

or: $4H = ½ gt^2$ 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 $3T$ cso

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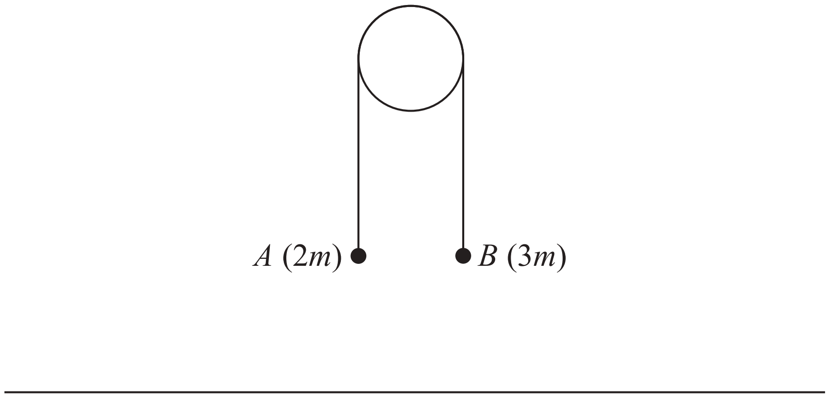

Figure 2

Two particles A and B have masses $2m$ and $3m$ respectively. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut. The hanging parts of the string are vertical and A and B are above a horizontal plane, as shown in Figure 2. The system is released from rest.

(a) Show that the tension in the string immediately after the particles are released is $\frac{12}{5}mg$.

(6)

After descending 1.5 m, B strikes the plane and is immediately brought to rest. In the subsequent motion, A does not reach the pulley.

(b) Find the distance travelled by A between the instant when B strikes the plane and the instant when the string next becomes taut.

(6)

Given that $m = 0.5$ kg,

(c) find the magnitude of the impulse on B due to the impact with the plane.

(2)

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)

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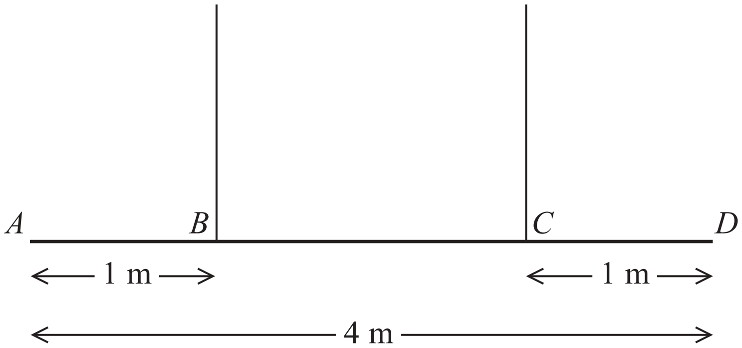

Figure 3

A non-uniform beam AD has weight W newtons and length 4 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. The ropes are attached to two points B and C on the beam, where $AB = 1$ m and $CD = 1$ m, as shown in Figure 3. The tension in the rope attached to C is double the tension in the rope attached to B. The beam is modelled as a rod and the ropes are modelled as light inextensible strings.

(a) Find the distance of the centre of mass of the beam from A.

(6)

A small load of weight kW newtons is attached to the beam at D. The beam remains in equilibrium in a horizontal position. The load is modelled as a particle.

Find

(b) an expression for the tension in the rope attached to B, giving your answer in terms of k and W,

(3)

(c) the set of possible values of k for which both ropes remain taut.

(2)

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

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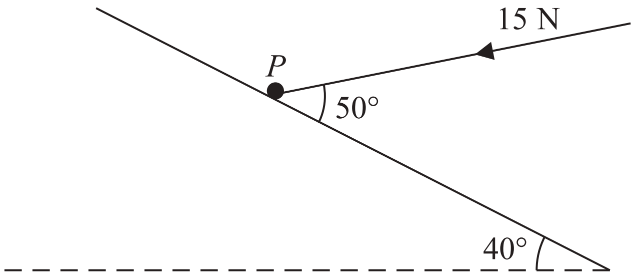


Figure 4

A particle P of mass 2.7 kg lies on a rough plane inclined at 40° to the horizontal. The particle is held in equilibrium by a force of magnitude 15 N acting at an angle of 50° to the plane, as shown in Figure 4. The force acts in a vertical plane containing a line of greatest slope of the plane. The particle is in equilibrium and is on the point of sliding down the plane.

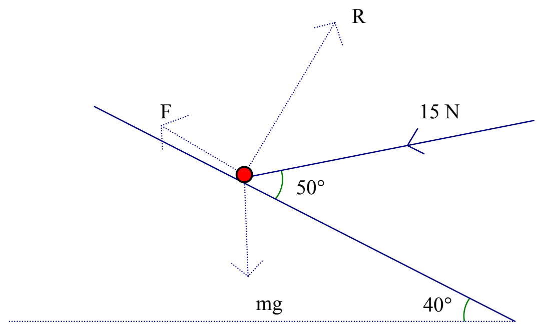
Find

(a) the magnitude of the normal reaction of the plane on P,
(4)

(b) the coefficient of friction between P and the plane.
(5)

The force of magnitude 15 N is removed.

(c) Determine whether P moves, justifying your answer.
(4)

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

Notes for Question 7

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

<u>Question 7(a)</u>
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)

<u>Question 7(b)</u>
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

<u>Question 7(c)</u>
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.