Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1
Bronze Level B4

Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Green)	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, differentiation and integration, or have retrievable mathematical formulas stored in them.

Instructions to Candidates

Write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M1), the paper reference (6677), your surname, initials and signature.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
There are 8 questions in this question paper. The total mark for this paper is 75.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner.
Answers without working may gain no credit.

Suggested grade boundaries for this paper:

A*	A	B	C	D	E
72	65	59	51	46	40

1. Particle P has mass 3 kg and particle Q has mass m kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision, the speed of P is 4 m s^{-1} and the speed of Q is 3 m s^{-1}. In the collision the direction of motion of P is unchanged and the direction of motion of Q is reversed. Immediately after the collision, the speed of P is 1 m s^{-1} and the speed of Q is 1.5 m s^{-1}.

(*a*) Find the magnitude of the impulse exerted on P in the collision.

(3)

(*b*) Find the value of m.

(3)

May 2013

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2. A steel girder AB, of mass 200 kg and length 12 m, rests horizontally in equilibrium on two smooth supports at C and at D, where AC = 2 m and DB = 2 m. A man of mass 80 kg stands on the girder at the point P, where AP = 4 m, as shown in Figure 1.

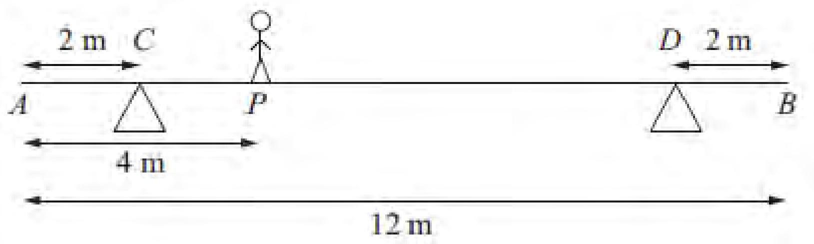

Figure 1

The man is modelled as a particle and the girder is modelled as a uniform rod.

(*a*) Find the magnitude of the reaction on the girder at the support at C.

(3)

The support at D is now moved to the point X on the girder, where XB = x metres. The man remains on the girder at P, as shown in Figure 2.

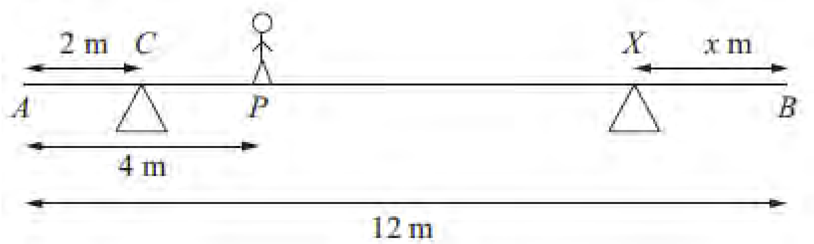

Figure 2

Given that the magnitudes of the reactions at the two supports are now equal and that the girder again rests horizontally in equilibrium, find

(*b*) the magnitude of the reaction at the support at X,

(2)

(*c*) the value of x.

(4)

January 2013

3.

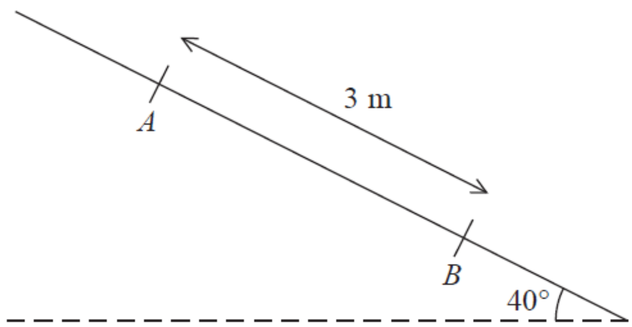

Figure 3

A rough plane is inclined at 40° to the horizontal. Two points *A* and *B* are 3 metres apart and lie on a line of greatest slope of the inclined plane, with *A* above *B*, as shown in Figure 3. A particle *P* of mass *m* kg is held at rest on the plane at *A*. The coefficient of friction between *P* and the plane is $\frac{1}{2}$. The particle is released.

(*a*) Find the acceleration of *P* down the plane.

(5)

(*b*) Find the speed of *P* at *B*.

(2)

June 2014

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4. A small stone is projected vertically upwards from a point *O* with a speed of 19.6 m s^{-1}. Modelling the stone as a particle moving freely under gravity,

(*a*) find the greatest height above *O* reached by the stone,

(2)

(*b*) find the length of time for which the stone is more than 14.7 m above *O*.

(5)

June 2015

5.

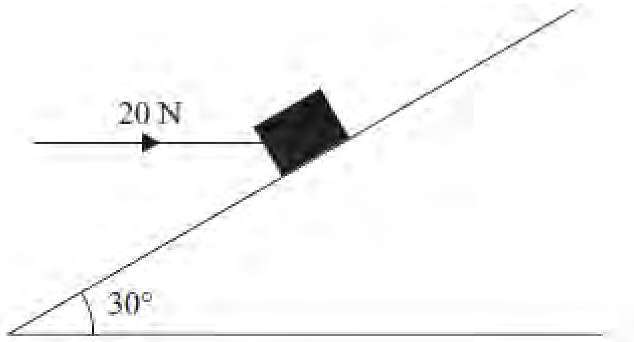

Figure 2

A box of mass 5 kg lies on a rough plane inclined at 30° to the horizontal. The box is held in equilibrium by a horizontal force of magnitude 20 N, as shown in Figure 2. The force acts in a vertical plane containing a line of greatest slope of the inclined plane.

The box is in equilibrium and on the point of moving down the plane. The box is modelled as a particle.

Find

(*a*) the magnitude of the normal reaction of the plane on the box,

(4)

(*b*) the coefficient of friction between the box and the plane.

(5)

May 2012

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6. A small brick of mass 0.5 kg is placed on a rough plane which is inclined to the horizontal at an angle θ, where $\tan\theta = \frac{4}{3}$, and released from rest. The coefficient of friction between the brick and the plane is $\frac{1}{3}$.

Find the acceleration of the brick.

(9)

May 2009

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7. A particle P of mass 0.5 kg is moving under the action of a single force $(3\mathbf{i} - 2\mathbf{j})$ N.

(*a*) Show that the magnitude of the acceleration of P is $2\sqrt{13}$m s^{-2}.

(4)

At time $t = 0$, the velocity of P is $(\mathbf{i} + 3\mathbf{j})$ m s^{-1}.

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

(3)

Another particle Q moves with constant velocity $\mathbf{v} = (2\mathbf{i} - \mathbf{j})$ m s^{-1}.

(*c*) Find the distance moved by Q in 2 seconds.

(2)

(*d*) Show that at time $t = 3.5$ seconds both particles are moving in the same direction.

(3)

June 2014

8.

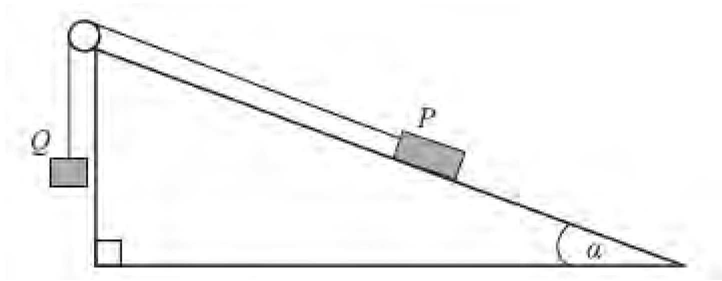


Figure 5

Two particles P and Q have masses 0.3 kg and m kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a fixed rough plane. The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between P and the plane is $\frac{1}{2}$.

The string lies in a vertical plane through a line of greatest slope of the inclined plane. The particle P is held at rest on the inclined plane and the particle Q hangs freely below the pulley with the string taut, as shown in Figure 5.

The system is released from rest and Q accelerates vertically downwards at 1.4 m s^{-2}.

Find

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

(2)

(*b*) the value of m.

(8)

When the particles have been moving for 0.5 s, the string breaks. Assuming that P does not reach the pulley,

(*c*) find the further time that elapses until P comes to instantaneous rest.

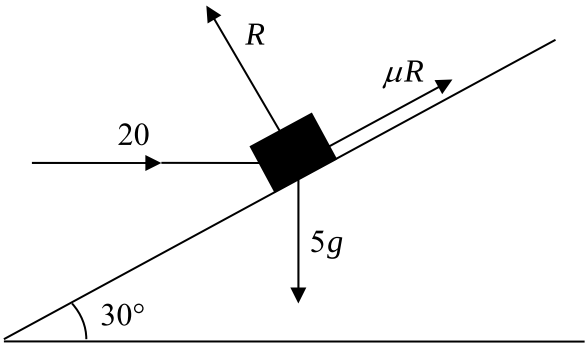
(6)

May 2011

TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)	For P, $-I = 3(1-4)$ $I = 9$ Ns	M1 A1 A1 **(3)**
(b)	For Q, $9 = m(1.5 - -3)$ $m = 2$ **OR** $12 - 3m = 3 + 1.5m$ $m = 2$	M1 A1 A1 M1 A1 A1 **(3)** **[6]**
2 (a)	$M(D)$, $8R = (80g \text{ x } 6) + (200g \text{ x } 4)$ $R = 160g$, 1600, 1570	M1 A1 A1 **(3)**
(b)	$(\uparrow)$, $2S = 80g + 200g$ $S = 140g$, 1400, 1370	M1 A1 **(2)**
(c)	$M(B)$, $Sx + (S \text{ x } 10) = (80g \text{ x } 8) + (200g \text{ x } 6)$ $140x + 1400 = 640 + 1200$ $140x = 440$ $x = \frac{22}{7}$	M1 A2 A1 **(4)** **[9]**
3 (a)	$R = mg\cos 40$ Use of $F = \mu R$ $mg\sin 40 - F = \pm ma$ $acc = 2.55$ (m s^{-2}) or 2.5 (m s^{-2})	B1 B1 M1A1 A1 **(5)**
(b)	$v^2 = u^2 + 2as = 2 \times a \times 3$ Speed at B is 3.9 (m s^{-1}) or 3.91(m s^{-1})	M1A1 **(2)** **[7]**

Question number	Scheme	Marks
4 (a)	$0^2 = 19.6^2 - 2\times gH$	M1
	$H = 19.6\text{m } (20)$	A1
		(2)
(b)	$14.7 = 19.6t - \frac{1}{2}gt^2$	M1 A1
	$t^2 - 4t + 3 = 0$	
	$(t-1)(t-3) = 0$	DM1
	$t = 1$ or 3; Answer 2 s	A1; A1
		(5)
		[7]
5 (a)		
	$\perp$ plane $R = 20\cos 60° + 5g\cos 30°$	M1 A2(1,0)
	$= 52.4\ (\text{N})$ or 52	A1
		(4)
(b)	$F_r = \mu R$	B1
	$\parallel$ plane $F + 20\cos 30° = 5g\cos 60°$	M1 A2(1, 0)
	Leading to $\mu = 0.137$ or 0.14	A1
		(5)
		[9]

Question number	Scheme	Marks
6	$0.5g\sin\theta - F = 0.5a$	M1 A1 A1
	$F = \frac{1}{3}R$ seen	B1
	$R = 0.5g\cos\theta$	M1 A1
	Use of $\sin\theta = \frac{4}{5}$ or $\cos\theta = \frac{3}{5}$ or decimal equiv or decimal angle e.g 53.1° or 53°	B1
	$a = \dfrac{3g}{5}$ or 5.88 m s^{-2} or 5.9 m s^{-2}	DM1 A1
		[9]
7 (a)	$\mathbf{F} = m\boldsymbol{a}$: $3\mathbf{i} - 2\mathbf{j} = 0.5\boldsymbol{a}$	M1
	$\boldsymbol{a} = 6\mathbf{i} - 4\mathbf{j}$	A1
	$\lvert\boldsymbol{a}\rvert = \sqrt{6^2 + (-4)^2} = 2\sqrt{13}$ **(m s^{-2}) ****	M1A1
		(4)
(b)	$\boldsymbol{v} = \boldsymbol{u} + \boldsymbol{a}t$: $\boldsymbol{v} = (\mathbf{i} + 3\mathbf{j}) + 2(6\mathbf{i} - 4\mathbf{j})$	M1A1 **ft**
	$= 13\mathbf{i} - 5\mathbf{j}$ m s^{-1}	A1
		(3)
(c)	Distance = $2\lvert\mathbf{v}\rvert = 2\sqrt{4+1} = 2\sqrt{5} = 4.47$ **(m)**	M1A1
		(2)
(d)	When $t = 3.5$, velocity of P is $(\mathbf{i} + 3\mathbf{j}) + 3.5(6\mathbf{i} - 4\mathbf{j}) = 22\mathbf{i} - 11\mathbf{j}$	M1A1 **ft**
	Given conclusion reached correctly. E.g. $22\mathbf{i} - 11\mathbf{j} = 11(2\mathbf{i} - \mathbf{j})$	A1
		(3)
		[12]

Question number	Scheme	Marks
8 (a)	$R = 0.3g\cos\alpha$	M1
	$= 0.24g = 2.35$ (3sf)=2.4 (2sf)	A1
		(2)
(b)	$mg - T = 1.4m$	M1 A1
	$T - 0.3g\sin\alpha - F = 0.3 \text{ x } 1.4$	M1 A2
	$F = 0.5R$	M1
	Eliminating R and T	**DM**1
	$m = 0.4$	A1
		(8)
(c)	$v = 1.4 \text{ x } 0.5$	B1
	$-0.3g\sin\alpha - F = 0.3a$	M1 A1
	$a = -9.8$	A1
	$0 = 0.7 - 9.8t$	M1
	$t = 0.071$ s or 0.0714 s (1/14 A0)	A1
		(6)
		[16]

Examiner reports

Question 1

This question was generally well answered. In part (a), almost all candidates quoted and used an appropriate formula for impulse in terms of difference of momenta. Since the magnitude of the impulse was asked for, a positive value was required for the final mark. If the impulse on Q rather than P was considered, to be eligible for a method mark it was necessary to find and substitute a value for m. The majority of candidates chose to use a 'conservation of linear momentum' equation in part (b). There were occasional sign, miscopying or arithmetical errors, but these were rare, and full marks were often achieved. Those who chose to use an impulse equation for the other particle generally did so successfully.

Question 2

There were many excellent solutions with the better candidates clearly stating the points about which they were taking moments. Very few candidates produced dimensionally incorrect equations or left out g's but a significant majority lost an accuracy mark in either (a) or (b). In part (a) the majority chose to take moments about D so finding the reaction in one step. It was helpful to the candidates that, if marks were lost in part (a), this did not prevent them from picking up all of the remaining marks since part (b) led into part (c) and most found part (b) straightforward. Very few fell into the trap of using data from (a) in the ensuing solution and very few had rounding errors in their final answer. Part (c) was surprisingly completely correct in some cases after poor performance in parts (a) and/or (b). Apart from really poor solutions, most marks were lost through using incorrect distances when taking moments. However there were some good accurate alternative solutions to part (c) showing competent use of algebra, with candidates choosing to take taking moments about a variety of points, with B and C being the most popular.

Question 3

There were many fully correct solutions to this question. The majority resolved correctly, although a small number did mix up sine and cosine, and some did omit one term from their equation of motion along the plane. Many wrote equations that initially equated weight and friction, but on realising that they needed an acceleration started again to give a correct solution. Omission of g was sometimes seen or g was included in the ma g term. However, almost everybody included $F = \mu R$, which gained them at least one mark.

Almost everybody was able to gain at least the method mark in part (b). There seemed to be less of an issue with over accuracy than seen in previous sessions, so the message appears to be getting through. As in question 1, there was an issue with premature rounding of the answer to part (a), leading to an inaccurate answer of 2.54 in part (b) if given to 3 significant figures. Some also forgot to square root at the end.

Question 4
Part (a) caused very few problems with nearly all candidates getting the correct answer. Most errors were arithmetical or sign errors. The second part was far more problematic, with a number of different methods being used. The direct approach was generally the most successful, although many forgot or didn't realise that they needed to find the difference in the times to earn the final mark. When the velocity at a height of 14.7 m was found, candidates were far more likely to get confused over initial/final velocities, although many did manage to get to the correct answer. It was disappointing to see how many failed to realise that they could just double their answer and instead chose (generally different approaches!) to find an upwards and downwards time. Some candidates seemed unclear as to which part of the motion they were dealing with, e.g. using $19.6 = 19.6t - \frac{1}{2}gt^2$. A few simply found the time to the maximum height. The quadratic formula was the most common approach to solve the resulting quadratic, with relatively few candidates spotting the common factor and straightforward factorisation. Others used their calculators so lost the method mark if incorrect solutions were found.

Question 5
This was a well-answered question. The majority of candidates obtained the correct number of terms in the resolutions and were able to resolve properly, with most candidates making sensible choices of the methods to use. Common errors were due to wrong signs, specifically with the 20 component, or missing g. There were also a few instances of division by sin or cos or the use of tan. A few candidates also neglected the weight in their resolving. The vast majority of candidates opted to resolve perpendicular and parallel to the plane. Of the few who chose to resolve horizontally and vertically most were successful but a few left out a component. There were surprisingly many candidates who lost the final mark through over-accuracy.

Virtually all candidates gained the mark for the use of $F = \mu R$. A significant number did not realise that friction acted up the plane and the ensuing negative value for μ was then conveniently lost. It seemed that fewer candidates than in previous years made the mistake of using $g = 9.81$.

There was evidence of a few candidates having their calculators set in radians rather than in degrees.

Question 6
This question was well done by the majority of candidates. Most made valid attempts at resolving parallel and perpendicular to the plane. The most common error was where candidates obtained the sin/cos of the complementary angle. Others used sin(4/5) or cos(3/5). Many successful candidates used the actual angle 53.1 rather than working with fractions for the trig. ratios. Some thought that the friction force was 1/3. A few managed to obtain the "correct" answer fortuitously by using $R = 0.5a$.

Question 7

In part (a) almost all students were able to use $\mathbf{F} = m\mathbf{a}$ to find the correct vector for the acceleration and then its magnitude or to find the magnitude of the force and then apply $|\mathbf{F}| = m|\mathbf{a}|$ to find the magnitude of the acceleration. As this was a 'show that' question, students needed to earn their marks and show sufficient stages in their argument and all too frequently, stages were omitted resulting in loss of marks. In the second part several students scored no marks for using the force rather than acceleration vector and some contrived to use the scalar magnitude combined with an initial vector velocity which also lost all the marks.

Part (c) was probably the most successful for students but a number left their answer as a vector and so gained no marks. In the final part, many students calculated $(\mathbf{i} + 3\mathbf{j}) + 3.5(6\mathbf{i} - 4\mathbf{j}) = 22\mathbf{i} - 11\mathbf{j}$ to gain the first two marks. Few chose the simplest explanation of motion being in the same direction by factorising $(22\mathbf{i} - 11\mathbf{j}) = 11(2\mathbf{i} - \mathbf{j})$ and there were many responses referring to either the bearing or gradient of both velocities. A few students started with the parallel idea and found the time to be unique at $t = 3.5$.

Question 8

This question proved to be very discriminating, particularly part (c). There were an impressive number of correct solutions to the first two parts. A mark was often lost in part (a) due to over accuracy whilst a few got their sines and cosines mixed up and others left out *g*. In the second part it was rare to see an attempt at the whole system solution and too often the friction or the weight component was left out of the appropriate equation. The vast majority considered the two particles separately and most candidates who obtained correct equations were able to obtain the correct value of *m* without further algebraic errors. The final part proved to be considerably more difficult. Many found the speed of *P* when the string broke but then failed to appreciate that they had to then find the new deceleration before they could move on, with many just assuming it was *g*, without justification. A number of candidates had the masses the wrong way round but could still pick up the majority of the marks.

Statistics for M1 Practice Paper Bronze Level B4

Qu	Max score	Modal score	Mean %	Mean score for students achieving grade: ALL	A*	A	B	C	D	E	U
1	6	6	89	5.32	5.89	5.81	5.63	5.48	5.25	4.91	3.58
2	9	9	74	6.62	8.10	7.96	6.95	5.73	4.47	2.88	1.55
3	7		81	5.64	6.77	6.56	6.14	5.65	4.92	4.04	2.32
4	7	7	84	5.86	6.83	6.64	6.16	5.74	5.32	4.69	3.37
5	9		78	7.06	8.72	8.52	7.90	7.17	6.23	4.95	2.53
6	9		77	6.89		8.52	7.76	6.88	5.64	4.67	2.24
7	12		67	8.05	11.11	10.22	8.51	7.30	6.18	5.28	3.31
8	16		52	8.27	13.59	12.18	9.10	6.64	4.61	2.97	1.21
	75		**71.61**	**53.71**	**61.01**	**66.41**	**58.15**	**50.59**	**42.62**	**34.39**	**20.11**