Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Silver Level S2

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
67	59	52	45	38	30

1. Two particles P and Q have masses $4m$ and m respectively. The particles are moving towards each other on a smooth horizontal plane and collide directly. The speeds of P and Q immediately before the collision are $2u$ and $5u$ respectively. Immediately after the collision, the speed of P is $\frac{1}{2}u$ and its direction of motion is reversed.

(*a*) Find the speed and direction of motion of Q after the collision.

(4)

(*b*) Find the magnitude of the impulse exerted on P by Q in the collision.

(3)

January 2013

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2. A particle P moves with constant acceleration $(2\mathbf{i} - 5\mathbf{j})$ m s^{-2}. At time $t = 0$, P has speed u m s^{-1}. At time $t = 3$ s, P has velocity $(-6\mathbf{i} + \mathbf{j})$ m s^{-1}.

Find the value of u.

(5)

January 2009

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3. A small ball is projected vertically upwards from ground level with speed u m s^{-1}. The ball takes 4 s to return to ground level.

(*a*) Draw, in the space below, a velocity-time graph to represent the motion of the ball during the first 4 s.

(2)

(*b*) The maximum height of the ball above the ground during the first 4 s is 19.6 m. Find the value of u.

(3)

January 2009

4.

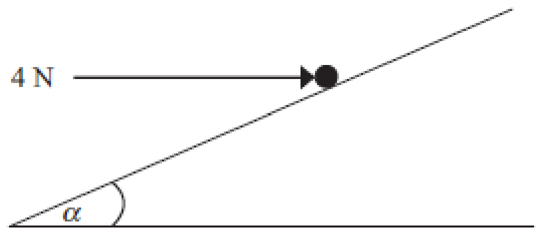

Figure 1

A particle of weight W newtons is held in equilibrium on a rough inclined plane by a horizontal force of magnitude 4 N. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$ as shown in Figure 1.

The coefficient of friction between the particle and the plane is $\frac{1}{2}$.

Given that the particle is on the point of sliding down the plane,

(i) show that the magnitude of the normal reaction between the particle and the plane is 20 N,

(ii) find the value of W.

(9)

May 2011

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5. A particle of mass 0.8 kg is held at rest on a rough plane. The plane is inclined at 30° to the horizontal. The particle is released from rest and slides down a line of greatest slope of the plane. The particle moves 2.7 m during the first 3 seconds of its motion. Find

(*a*) the acceleration of the particle,

(3)

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

(5)

The particle is now held on the same rough plane by a horizontal force of magnitude X newtons, acting in a plane containing a line of greatest slope of the plane, as shown in Figure 2. The particle is in equilibrium and on the point of moving up the plane.

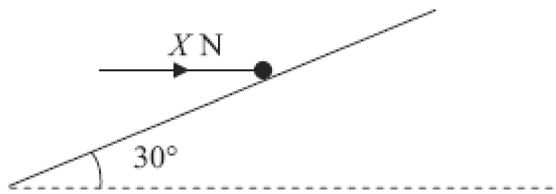

Figure 2

(c) Find the value of X.

(7)

January 2010

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6. A plank PQR, of length 8 m and mass 20 kg, is in equilibrium in a horizontal position on two supports at P and Q, where $PQ = 6$ m.

A child of mass 40 kg stands on the plank at a distance of 2 m from P and a block of mass M kg is placed on the plank at the end R. The plank remains horizontal and in equilibrium. The force exerted on the plank by the support at P is equal to the force exerted on the plank by the support at Q.

By modelling the plank as a uniform rod, and the child and the block as particles,

(*a*) (i) find the magnitude of the force exerted on the plank by the support at P,

(ii) find the value of M.

(10)

(*b*) State how, in your calculations, you have used the fact that the child and the block can be modelled as particles.

(1)

May 2011

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7. [*In this question, the horizontal unit vectors* **i** *and* **j** *are directed due east and due north respectively*.]

The velocity, **v** m s^{-1}, of a particle P at time t seconds is given by

$$\mathbf{v} = (1 - 2t)\mathbf{i} + (3t - 3)\mathbf{j}.$$

(*a*) Find the speed of P when $t = 0$.

(3)

(*b*) Find the bearing on which P is moving when $t = 2$.

(2)

(*c*) Find the value of t when P is moving

(i) parallel to **j**,

(ii) parallel to $(-\mathbf{i} - 3\mathbf{j})$.

(6)

May 2013

8.

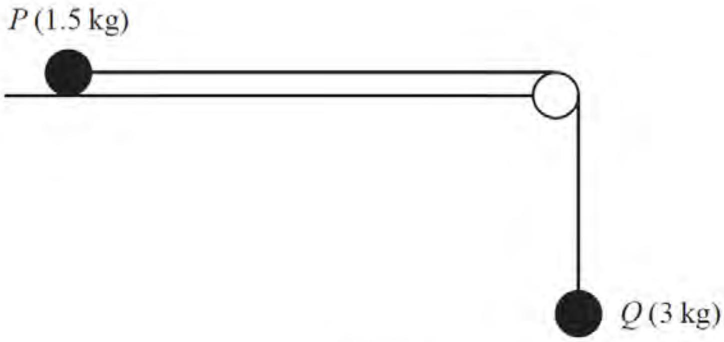


Figure 3

Two particles P and Q have masses 1.5 kg and 3 kg respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a fixed rough horizontal table. The coefficient of friction between P and the table is $\frac{1}{5}$. The string is parallel to the table and passes over a small smooth light pulley which is fixed at the edge of the table. Particle Q hangs freely at rest vertically below the pulley, as shown in Figure 3. Particle P is released from rest with the string taut and slides along the table.

Assuming that P has not reached the pulley, find

(a) the tension in the string during the motion,

(8)

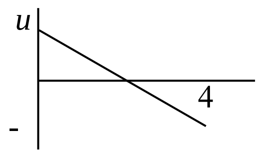
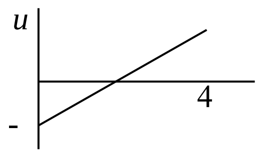
(b) the magnitude and direction of the resultant force exerted on the pulley by the string.

(4)

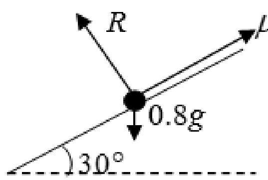
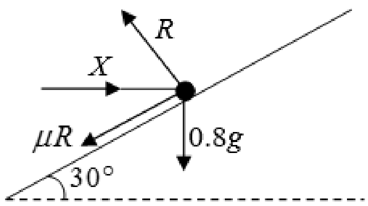
June 2016

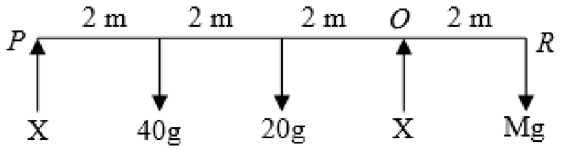
TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)	$4m.2u - m.5u = -4m.\tfrac{1}{2}u + mv$ $3mu = -2mu + mv$ $v = 5u$, opposite direction	M1 A1 A1; A1 **cso** **(4)**
(b)	$I = 4m(\tfrac{1}{2}u - -2u)$ OR $I = m(5u - -5u)$ $= 10mu$ $= 10mu$	M1 A1 A1 **(3)** **[7]**
2	$-6\mathbf{i} + \mathbf{j} = \mathbf{u} + 3(2\mathbf{i} - 5\mathbf{j})$ $\Rightarrow \mathbf{u} = -12\mathbf{i} + 16\mathbf{j}$ $\Rightarrow u = \sqrt{(-12)^2 + 16^2} = 20$	M1 A1 A1 cso M1 A1 **[5]**
3 (a)	 or  shape values	B1 B1 **(2)**
(b)	$19.6 = \frac{1}{2} \times 2 \times u$ $u = 19.6$	M1 A1 A1 **(3)** **[5]**

Question number	Scheme	Marks
4	$\nearrow$ $4\cos\alpha + F = W\sin\alpha$	M1 A1
	$\nwarrow$ $R = 4\sin\alpha + W\cos\alpha$	M1 A1
	$F = 0.5R$	B1
	$\cos\alpha = 0.8$ or $\sin\alpha = 0.6$	B1
	$R = 20N$ ** GIVEN ANSWER	M1 A1
	$W = 22N$	A1
	OR	**[9]**
	$\rightarrow$ $R\sin\alpha = 4 + F\cos\alpha$	M1 A1
	$\uparrow$ $R\cos\alpha + F\sin\alpha = W$	M1 A1
	$F = 0.5R$	B1
	$\cos\alpha = 0.8$ or $\sin\alpha = 0.6$	B1
	$R = 20N$ ** GIVEN ANSWER	M1 A1
	$W = 22N$	A1
		[9]

Question number	Scheme	Marks
5 (a)	$s = ut + \frac{1}{2}at^2 \quad \Rightarrow \quad 2.7 = \frac{1}{2}a \times 9$	M1 A1
	$a = 0.6\ (\text{m s}^{-2})$	A1
		(3)
(b)		
	↖ $R = 0.8g\cos 30°\ (\approx 6.79)$	B1
	Use of $F = \mu R$	B1
	↙ $0.8g\sin 30° - \mu R = 0.8 \times a$	M1 A1
	$(0.8g\sin 30° - \mu 0.8g\cos 30° = 0.8 \times 0.6)$	
	$\mu \approx 0.51$ accept 0.507	A1
		(5)
(c)		
	↑ $R\cos 30° = \mu R\cos 60° + 0.8g$	M1 A2 (1,0)
	$(R \approx 12.8)$	
	→ $X = R\sin 30° + \mu R\sin 60°$	M1 A1
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1
		(7)
		[15]
	Alternative to (c)	
	↖ $R = X\sin 30° + 0.8 \times 9.8\sin 60°$	M1 A2 (1,0)
	↙ $\mu R + 0.8g\cos 60° = X\cos 30°$	M1 A1
	$X = \dfrac{\mu 0.8g\sin 60° + 0.8g\cos 60°}{\cos 30° - \mu\sin 30°}$	
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1
		(7)

Question number	Scheme	Marks
6 (a)	 	
(i)	**EITHER** M(R), $8X + 2X = 40\text{g} \times 6 + 20\text{g} \times 4$	M1 A2
	solving for X, $X = 32\text{g} = 314$ or 310 N	M1 A1
(ii)	(↑) $X + X = 40\text{g} + 20\text{g} + M\text{g}$ (or another moments equation)	M1 A2
	solving for M, $M = 4$	M1 A1
(i)	**OR** M(P), $6X = 40\text{g} \times 2 + 20\text{g} \times 4 + M\text{g} \times 8$	M1 A2
	solving for X, $X = 32\text{g} = 314$ or 310 N	M1 A1
	(↑) $X + X = 40\text{g} + 20\text{g} + M\text{g}$ (or another moments equation)	M1 A2
(ii)	solving for M, $M = 4$	M1 A1
		(10)
(b)	Masses concentrated at a point or weights act at a point	B1
		(1)
		[11]
7 (a)	$t = 0$ gives $\mathbf{v} = \mathbf{i} - 3\mathbf{j}$	B1
	speed $= \sqrt{1^2 + (-3)^2}$	M1
	$= \sqrt{10} = 3.2$ or better	A1
		(3)
(b)	$t = 2$ gives $\mathbf{v} = (-3\mathbf{i} + 3\mathbf{j})$	M1
	Bearing is $315°$	A1
		(2)
(c)	$1 - 2t = 0$ □ $t = 0.5$	M1 A1
	$-(3t - 3) = -3(1 - 2t)$	M1 A1
	Solving for t	**DM**1
	t = 2/3, 0.67 or better	A1
		(6)
		[11]

Question number	Scheme	Marks
8 (a)	$F = \frac{1}{5}R$	M1
	$R = 1.5g$	B1
	$T - F = 1.5a$	M1 A1
	$3g - T = 3a$	M1 A1
	$T = 1.2g$ or 11.8 N or 12 N	**DM1** A1
		(8)
(b)	$R = \sqrt{T^2 + T^2}$ or $2T\cos 45^0$ or $\dfrac{T}{\cos 45^0}$	M1 A1
	$= 16.6$ (N) or 17(N) or $\dfrac{6g\sqrt{2}}{5}$	A1
	Direction is 45° below the horizontal oe	B1
		(4)
		[12]

Examiner reports

Question 1

The vast majority of candidates wrote down an appropriate ‘conservation of linear momentum’ equation for part (a). There were occasional sign errors and the few who tried to equate impulses often did not take account of directions. Most reached the required positive value for speed ($5u$) but, those who took the opposite direction as positive, sometimes left their answer as $–5u$ and lost a mark. It was important that the subsequent direction of motion of Q was described in the context of the problem (such as ‘direction reversed’ or ‘opposite direction’) and not relative to the candidate’s diagram (such as ‘to the right’ or by drawing an arrow). In the second part almost all quoted and used a correct impulse formula, applying it to either the motion of P or Q. The relevant velocities for P were given in the question, so there were no follow through accuracy marks for those who chose to use the impulse on Q with a wrong value from part (a). Sometimes direction was not properly accounted for leading to a sign error. Since the magnitude of the impulse was asked for, the positive value ‘$10mu$’ was required for the final mark. Following correct working, some candidates wrongly stated the magnitude as ‘10’. Nevertheless, there were many entirely correct solutions seen.

Question 2

Most candidates realised that they needed to apply $\mathbf{v} = \mathbf{u} + \mathbf{a}\,t$ and many arrived at $12\mathbf{i} – 16\mathbf{j}$ but then failed to go on and find the speed, losing the final two marks. This showed a lack of understanding of the relationship between speed and velocity. A small minority found magnitudes at the start and then tried to use $v = u + at$, gaining no marks. Some candidates lost the third mark because of errors in the manipulation of negative numbers.

Question 3

Only a relatively small number of candidates had a correct graph in part (a). There was a whole variety of incorrect attempts seen. Many of the graphs were curved and in some cases the path that the ball would take in the air was drawn. Of those who had a straight line many were reluctant to go below the t-axis into negative velocities and drew a speed-time graph instead. Part (b) was more successfully answered but a common error was to use a wrong time value. Students generally used constant acceleration formulae rather than the area under their graph.

Question 4

Although unstructured, this question provided a familiar scenario and was a good source of marks for many candidates. Most chose to resolve parallel and perpendicular to the plane despite the fact that horizontal and vertical resolutions lead to a much more straightforward solution. There were the usual problems of sign errors, with the friction often acting in the wrong direction, extra g’s, a few sine/cosine mix ups and some poor algebra. Even those who had no idea how to solve their simultaneous equations could substitute $R = 20$ into one equation and find a value for W. A significant number of candidates resorted to finding the angle on their calculators or never mentioned sine/cosine = 0.6/0.8, thus losing the B mark and perhaps an accuracy mark. A few used $R = 20$ to find W then used W to find R!

Question 5
Part (a) had a very high success rate and all three marks were regularly scored but the second part was found to be more challenging. Most were able to resolve perpendicular to the plane to find the reaction and use it to find the limiting friction. However, all too often there were omissions from the equation of motion parallel to the plane, either the mass x acceleration term and/or the weight component or else g was missing. Part (c) was a good discriminator and candidates needed to realise that this was a new system and that there was no acceleration. Those who failed to appreciate this and used their friction force from part (b) scored no marks. The majority of successful candidates resolved parallel and perpendicular to the plane (although a sizeable minority resolved vertically and horizontally) but even then a correct final answer was rarely seen due to premature approximation or else it was given to too many figures.

Question 6
Most candidates were able to produce two valid equations in part (a), with the majority using one moments and a vertical resolution. Occasionally g was omitted from the weight terms and, more rarely, a reaction was equated to the sum of moments; this led to a dimensionally incorrect equation and a significant loss of marks. A relatively small number of candidates misinterpreted the given information and included the supports in the wrong positions on the rod (often 1 m from the ends) while others failed to realise there were two reaction forces.

It was possible to find the value of the reaction directly by taking moments about R, but many found two equations and solved them simultaneously to find the reaction and then used it to find the value of M. A common error was to give the answer for the reaction as 313.6 which represents unjustifiable accuracy after using $g = 9.8$ (314, 310 or $32g$ were all acceptable).

Many comments in part (b) related to the concentration of mass at a point, or the weight acting through the point given; these achieved the mark. Some comments were irrelevant and just referred to, for example, weight acting downwards, or 'enabling moments to be taken'.

Question 7
In part (a) the vast majority obtained $\mathbf{i} - 3\mathbf{j}$, and only a few of these forgot to go on and find the speed. In the second part almost all tried to substitute $t = 2$, and almost all of these obtained -3i + 3j; there were, however, many errors in finding the bearing, with 225° being the most common incorrect answer. In part (c) (i) most candidates seemed to realise that something had to be equated to zero; approximately half of them took it to be the **i**-component of v, leading correctly to $t = \frac{1}{2}$. Of the remainder, some thought that the **j**-component should be zero, while a substantial number equated both components in turn to zero, obtaining two values for t. It was part (c) (ii) that proved to be a good discriminator. Many just gave up at this point, while some tried equating the **i**-component to –1 and the **j**-component to –3, again obtaining two values for t. Of those who knew how to proceed, the k-method seemed less error-prone than the 'going straight to the ratio' method, with perhaps less risk of ending up with the ratio the wrong way round. It was surprising to see how many found the value of k first, then substituted it back into one of their equations rather than just eliminating it immediately.

Question 8

This was an unstructured question but a fairly familiar scenario. Part (a) involved setting up equations of motion (one vertical and one horizontal) for the two particles and then solving them (by eliminating or finding the acceleration) to find the value of the tension. Most candidates gained two marks for correctly finding the normal reaction and using this to find the frictional force. Those who set up their equations correctly sometimes made numerical or processing slips in solving them, thereby losing the final mark in part (a). Nevertheless, an encouraging number of fully correct solutions were seen, with the final answer being rounded to 2 or 3 significant figures (following the use of $g = 9.8$), or given as $1.2g$.

Candidates generally seemed less familiar with an appropriate method for finding the resultant force exerted on the pulley by the string, as required in part (b). Some omitted it completely, or used forces other than the tensions. The most common successful approach was to resolve the two tension forces in the direction of the resultant which by symmetry is along the angle bisector, giving $2T \cos 45°$. The last mark was frequently lost as the direction of the resultant was not made clear, whether in words or with a diagram including 45° and an arrow. Bearings and references to south west etc were very common but gained no credit. If an incorrect value for the tension was carried forward from part (a), three out of the possible four marks were available in part (b).

Statistics for M1 Practice Paper Silver Level S2

Qu	Max score	Modal score	Mean %	Mean score for students achieving grade: ALL	A*	A	B	C	D	E	U
1	7	7	74	5.17	6.39	6.06	5.26	4.76	4.25	3.74	2.49
2	5		63	3.13		3.71	3.13	2.68	2.58	2.46	1.68
3	5		58	2.88		3.50	2.75	2.46	2.17	1.63	1.13
4	9		69	6.25	8.78	8.29	7.14	5.93	4.60	3.28	1.55
5	15		62	9.33		11.81	9.11	7.37	5.51	4.36	2.51
6	11		67	7.34	10.08	9.53	8.33	7.13	5.62	4.07	1.79
7	11	7	59	6.48	10.00	8.73	6.87	5.89	5.05	4.18	2.66
8	12	11	69	8.23	10.60	9.96	8.70	7.61	6.40	4.92	2.71
	75		**65.08**	**48.81**	**45.85**	**61.59**	**51.29**	**43.83**	**36.18**	**28.64**	**16.52**