Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Silver Level S1

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
70	62	53	45	37	28

1. A railway truck P, of mass m kg, is moving along a straight horizontal track with speed 15 m s^{-1}. Truck P collides with a truck Q of mass 3000 kg, which is at rest on the same track. Immediately after the collision the speed of P is 3 m s^{-1} and the speed of Q is 9 m s^{-1}. The direction of motion of P is reversed by the collision.

Modelling the trucks as particles, find

(*a*) the magnitude of the impulse exerted by P on Q,

(2)

(*b*) the value of m.

(3)

January 2012

2.

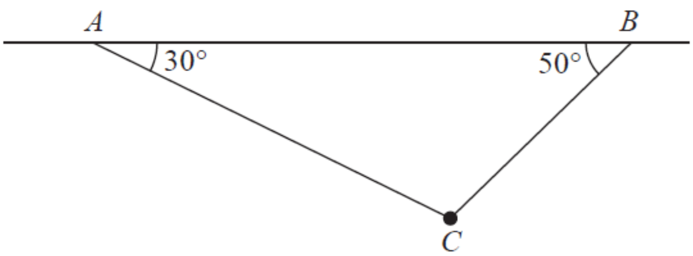

Figure 1

A particle of weight W newtons is attached at C to two light inextensible strings AC and BC. The other ends of the strings are attached to fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with AC and BC inclined to the horizontal at 30° and 50° respectively, as shown in Figure 1.

Given that the tension in BC is 6 N, find

(*a*) the tension in AC,

(3)

(*b*) the value of W.

(3)

June 2014

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3. A firework rocket starts from rest at ground level and moves vertically. In the first 3 s of its motion, the rocket rises 27 m. The rocket is modelled as a particle moving with constant acceleration a m s^{-2}. Find

(a) the value of a,

(2)

(b) the speed of the rocket 3 s after it has left the ground.

(2)

After 3 s, the rocket burns out. The motion of the rocket is now modelled as that of a particle moving freely under gravity.

(c) Find the height of the rocket above the ground 5 s after it has left the ground.

(4)

January 2008

4.

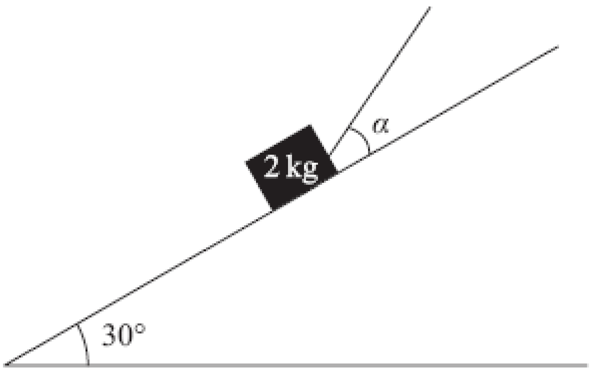

Figure 2

A box of mass 2 kg is held in equilibrium on a fixed rough inclined plane by a rope. The rope lies in a vertical plane containing a line of greatest slope of the inclined plane. The rope is inclined to the plane at an angle α, where $\tan \alpha = \frac{3}{4}$, and the plane is at an angle of 30° to the horizontal, as shown in Figure 2. The coefficient of friction between the box and the inclined plane is $\frac{1}{3}$ and the box is on the point of slipping up the plane. By modelling the box as a particle and the rope as a light inextensible string, find the tension in the rope.

(8)

May 2013

5.

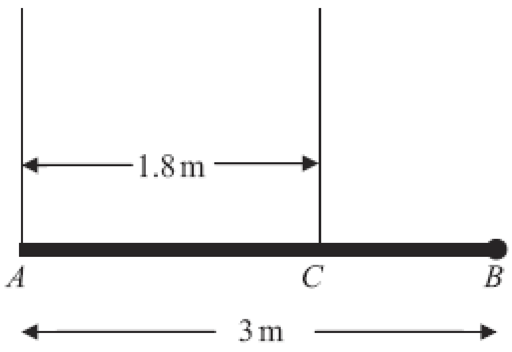

Figure 3

A pole AB has length 3 m and weight W newtons. The pole is held in a horizontal position in equilibrium by two vertical ropes attached to the pole at the points A and C where AC = 1.8 m, as shown in Figure 3. A load of weight 20 N is attached to the rod at B. The pole is modelled as a uniform rod, the ropes as light inextensible strings and the load as a particle.

(*a*) Show that the tension in the rope attached to the pole at C is $\left(\frac{5}{6}W + \frac{100}{3}\right)$ N.

(4)

(*b*) Find, in terms of W, the tension in the rope attached to the pole at A.

(3)

Given that the tension in the rope attached to the pole at C is eight times the tension in the rope attached to the pole at A,

(*c*) find the value of W.

(3)

January 2010

6. A non-uniform plank AB has length 6 m and mass 30 kg. The plank rests in equilibrium in a horizontal position on supports at the points S and T of the plank where AS = 0.5 m and TB = 2 m.

When a block of mass M kg is placed on the plank at A, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about S.

When the block is moved to B, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about T.

The distance of the centre of mass of the plank from A is d metres. The block is modelled as a particle and the plank is modelled as a non-uniform rod. Find

(i) the value of d,

(ii) the value of M.

(7)

June 2016

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7. A boat B is moving with constant velocity. At noon, B is at the point with position vector $(3\mathbf{i} - 4\mathbf{j})$ km with respect to a fixed origin O. At 1430 on the same day, B is at the point with position vector $(8\mathbf{i} + 11\mathbf{j})$ km.

(*a*) Find the velocity of B, giving your answer in the form $p\mathbf{i} + q\mathbf{j}$.

(3)

At time t hours after noon, the position vector of B is $\mathbf{b}$ km.

(*b*) Find, in terms of t, an expression for $\mathbf{b}$.

(3)

Another boat C is also moving with constant velocity. The position vector of C, $\mathbf{c}$ km, at time t hours after noon, is given by

$$\mathbf{c} = (-9\mathbf{i} + 20\mathbf{j}) + t(6\mathbf{i} + \lambda\mathbf{j}),$$

where λ is a constant.

Given that C intercepts B,

(*c*) find the value of λ,

(5)

(*d*) show that, before C intercepts B, the boats are moving with the same speed.

(3)

June 2007

8.

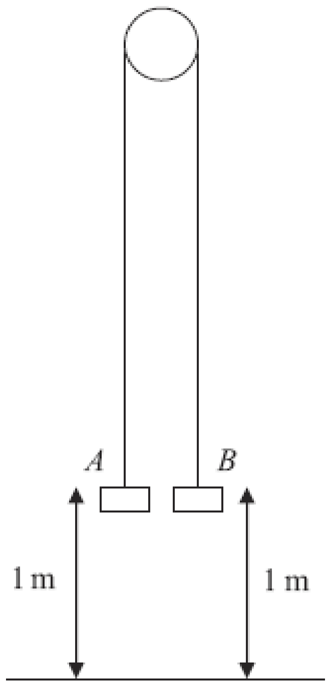


Figure 4

Two particles A and B have mass 0.4 kg and 0.3 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 above a horizontal floor. Both particles are held, with the string taut, at a height of 1 m above the floor, as shown in Figure 4. The particles are released from rest and in the subsequent motion B does not reach the pulley.

(a) Find the tension in the string immediately after the particles are released.

(6)

(b) Find the acceleration of A immediately after the particles are released.

(2)

When the particles have been moving for 0.5 s, the string breaks.

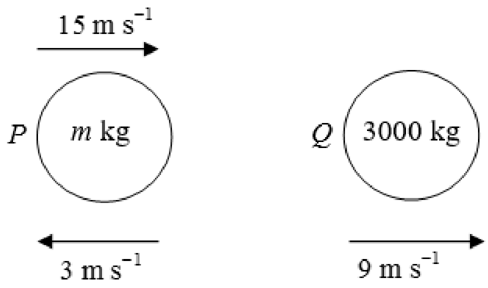
(c) Find the further time that elapses until B hits the floor.

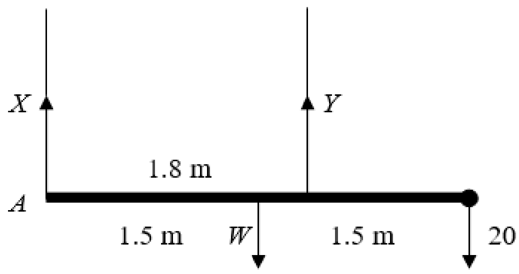
(9)

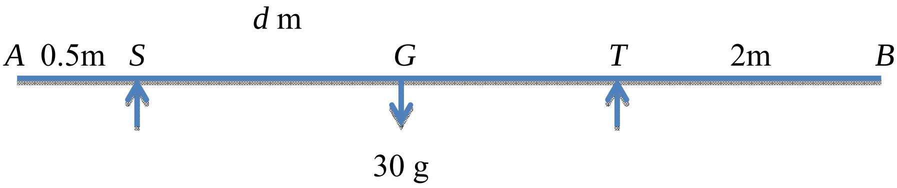
May 2010

TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)		
	For Q $\quad I = 3000 \times 9 = 27\,000 \quad (\text{N s})$	M1 A1
		(2)
(b)	Conservation of linear momentum	
	$15m = -3m + 3000 \times 9$	M1 A1
	Leading to $\quad m = 1500$	A1
		(3)
		[5]
2 (a)	Resolving horizontally: $T\cos 30° = 6\cos 50°$	M1A1
	$T = 4.45$ (N), 4.5 (N), or better	A1
		(3)
(b)	Resolving vertically: $W = 6\cos 40° + T\cos 60°$	M1A1
	$= 6.82$ (N), 6.8 (N), or better	A1
		(3)
		[6]
3 (a)	$27 = 0 + \frac{1}{2}.a.3^2 \quad \Rightarrow \quad a = \underline{6}$	M1 A1
		(2)
(b)	$v = 6 \times 3 = \underline{18 \text{ m s}^{-1}}$	M1 A1 ft
		(2)
(c)	From $t = 3$ to $t = 5$, $s = 18 \times 2 - \frac{1}{2} \times 9.8 \times 2^2$	M1 A1 ft
	Total ht. $= s + 27 = \underline{43.4 \text{ m}, \ 43 \text{ m}}$	M1 A1
		(4)
		[8]

Question number	Scheme	Marks
4	$T\cos\alpha - F = 2g\cos 60^o$ $T\sin\alpha + R = 2g\cos 30^o$ $F = \frac{1}{3}R$ eliminating F and R $T = g(1+\frac{1}{\sqrt{3}})$, 1.6g (or better), 15.5, 15 (N)	M1 A1 M1 A1 B1 **DM**1 **DM**1 A1 **[8]**
5 (a)	 M (A) $W\times1.5+20\times3=Y\times1.8$ $Y=\frac{5}{6}W+\frac{100}{3}$ * cso	M1 A2 (1, 0) A **(4)**
(b)	↑ $X+Y=W+20$ or equivalent $X=\frac{1}{6}W-\frac{40}{3}$	M1 A1 A1 **(3)**
(c)	$\frac{5}{6}W+\frac{100}{3}=8\left(\frac{1}{6}W-\frac{40}{3}\right)$ $W=280$	M1 A1 ft A1 **(3)** **[10]**
	Alternative to (b) M(C) $X\times1.8+20\times1.2=W\times0.3$ $X=\frac{1}{6}W-\frac{40}{3}$	M1 A1 A1

Question number	Scheme	Marks
6		
	$M(S)$: $Mg \times 0.5 = 30g(d-0.5)$	M1 A1
	$M(T)$: $Mg \times 2 = 30g(4-d)$	M1 A1
	dividing: $4 = \dfrac{(4-d)}{(d-0.5)}$ => (i) $d = 1.2$	**DM1** A1
	=> (ii) $M = 42$	A1
		[7]
7 (a)	$\mathbf{v} = \dfrac{8\mathbf{i}+11\mathbf{j}-(3\mathbf{i}-4\mathbf{j})}{2.5}$ or any equivalent	M1 A1
	$\mathbf{v} = 2\mathbf{i}+6\mathbf{j}$	A1
		(3)
(b)	$\mathbf{b} = 3\mathbf{i}-4\mathbf{j}+\mathbf{v}t$ ft their $\mathbf{v}$	M1 A1 ft
	$= 3\mathbf{i}-4\mathbf{j}+(2\mathbf{i}+6\mathbf{j})t$	A1cao
		(3)
(c)	$\mathbf{i}$ component: $-9+6t = 3+2t$	M1
	$t = 3$	M1 A1
	$\mathbf{j}$ component: $20+3\lambda = -4+18$	M1
	$\lambda = -2$	A1
		(5)
(d)	$v_B = \sqrt{(2^2+6^2)}$ or $v_C = \sqrt{(6^2+(-2)^2)}$	
	Both correct	A1
	The speeds of *B* and *C* are the same cso	A1
		(3)
		[14]

Question number	Scheme	Marks
8 (a)	$(\downarrow) 0.4g - T = 0.4a$	M1 A1
	$(\uparrow) T - 0.3g = 0.3a$	M1 A1
	solving for T	**DM1**
	$T = 3.36$ or 3.4 or $12g/35$ (N)	A1
		(6)
(b)	$0.4g - 0.3g = 0.7a$	**DM1**
	$a = 1.4$ m s^{-2}, $g/7$	A1
		(2)
(c)	$(\uparrow) v = u + at$	
	$v = 0.5 \text{ x } 1.4$	M1
	$= 0.7$	A1 ft on a
	$(\uparrow) s = ut + \frac{1}{2}at^2$	
	$s = 0.5 \text{ x } 1.4 \text{ x } 0.5^2$	M1
	$= 0.175$	A1 ft on a
	$(\downarrow) s = ut + \frac{1}{2}at^2$	
	$1.175 = -0.7t + 4.9t^2$	**DM1** A1 ft
	$4.9t^2 - 0.7t - 1.175 = 0$	
	$t = \frac{0.7 \pm \sqrt{0.7^2 + 19.6 \text{ x } 1.175}}{9.8}$	**DM1** A1 cao
	$= 0.5663..\text{or } -...$	
	Ans 0.57 or 0.566 s	A1 cao
		(9)
		[17]

Examiner reports

Question 1

This question seemed to pose few problems for the majority of candidates. In part (a) most found the magnitude of the impulse of *P* on *Q* with very few giving a negative answer. A few found the magnitude of the impulse on *P*, giving their answer in terms of *m*. A fairly common error was to include g in the impulse formula and this received no credit. In the second part, most used conservation of momentum and there were the usual sign errors. A few candidates struggled with re-arranging the equation.

Question 2

Overall this was a well-answered question and got the students off to a nice start. Most attempted to resolve horizontally and vertically. A few students attempted to resolve along the string but were usually unsuccessful. The only common error here was sine and cosine interchange. A small number attempted to use the sine rule, but the angles were usually wrong, often just using the angles shown in the diagram, rather than using an appropriate vector triangle. Lami's theorem was very rare, but generally done correctly.

Students who answered part (a) correctly often lost marks in part (b) due to premature rounding of their tension. The only other common error was to use *Wg* instead of *W* in part (b). A small number assumed that the angle at *C* was 90° and tried to resolve along the strings.

Question 3

Parts (a) and (b) were usually done correctly although there were a number of candidates who thought that velocity = distance/time and used this as a basis for the solutions to the first two parts of the question and there are still some who are unable to quote the '*suvat*' formulae correctly. The use of a "follow through" in the mark scheme was of great benefit to some students.

Part (c) caused more problems with many candidates using incorrect information in their equations. A few found the time to the top and then used the remaining time to work out the distance fallen.The continuity of the motion was the major stumbling block for students who produced incorrect solutions. Students wrongly used u=0, t=5 or the wrong acceleration here and there were many sign errors. A considerable number of students failed to use the '27' appropriately with students subtracting their answers from '27' or not even attempting this section. There are still students who forget that they need to explain work to the examiner rather than just quote an answer. The instructions on the front of the exam paper are clear.

Question 4

The vast majority of candidates recognised that this equilibrium question required the resolution of forces in two directions. These were almost invariably (and sensibly) chosen to be parallel and perpendicular to the inclined plane. Candidates who used any other directions tended to miss out at least one force component and so make no valid progress. The question involved two distinct angles (the angle of inclination of the slope and the angle that the rope makes with the plane); in some responses there was evidence of confusion between these. In the perpendicular direction, some equated the normal reaction to the weight component, omitting the component of tension and thereby over-simplifying the problem. Nearly all used $F = \frac{1}{3}R$ appropriately in trying to eliminate F and then R from their two equations and many handled the terms and substitutions systematically, reaching a correct value for the tension. A better use of brackets would have helped some candidates who struggled to simplify the working involved. If g = 9.8 had been substituted, then two or three significant figures were required for the final answer, although an accurate answer in terms of g was also acceptable. Many fully correct solutions were seen.

Question 5

This question was well done by the majority of candidates and was the next best answered question after 1 and 2. Most made valid attempts at taking moments, in part (a) about A and often also about C in part (b).The printed answer was an additional help to the less able students who were able to score the marks in part (b) by using it in a vertical resolution. There was some confusion in the last part over the interpretation and use of the information given. Correct statements of simply $Y = 8X$ or else $8X + X = W + 20$ were seen but also $X = 8Y$ was common as were the more surprising $X + 8Y = W + 20$ and $8X + Y = W + 20$, both of which scored nothing.

Question 6

There were several possible alternative approaches to solving this moments problem, but those candidates who failed to realise that 'on the point of tilting' implied that one of the reactions was zero could make no valid progress; they tended to waste time and effort in trying to solve a variety of equations in too many unknowns and much crossed out work was seen. Occasionally the wrong reaction was assumed to be zero, or it was assumed to be zero inconsistently in different equations. Sometimes the sum of the two reactions was equated to the total weight ($30g + Mg$). Clearly labelled separate diagrams of the two scenarios (mass at one end of rod and then at the other) would have helped some candidates to develop a more systematic approach and avoid such errors. The most straightforward method of solution was, for each case, to take moments about the pivot with the non-zero reaction, leading to simultaneous equations in d (distance) and M (mass). This was often completed successfully although errors in distances (such as $(6 - d)$ rather than $(4 - d)$ in the 'moments about T ' equation) were sometimes seen. Another valid approach was to find the reaction (which was the same in both situations) by vertical resolution and then use this in appropriate moments equations; this method was also employed with a fair degree of success although, again, there were occasional errors in relevant distances or in solving the subsequent equations. Inconsistent inclusion of g in the two weight terms was penalised although such instances were rare. There were a fair number of fully correct solutions seen.

Question 7

There was some evidence that a number of weaker candidates were unable to complete this question but it wasn't clear whether they ran out of time or simply couldn't do it. In parts (a) and (b) some candidates confused the use of position vectors and velocity vectors.

Part (a). This was well answered by most candidates. Where errors did occur they often involved adding the position vectors, not dividing by the time or miscalculating the time or else doing the subtraction incorrectly or the wrong way round.

Particular examples:-

errors in dividing by 2.5, particularly the **j**-component of the vector.
errors in time, using 2.3 or 4.5 hours.
some candidates changed the time into minutes, others into seconds.
not enough care was taken in looking at the compatibility of length and time units.
use of inappropriate formulae to solve the problem .

A few candidates clearly did not know how to deal with it at all.

Part (b). This was often correct. Errors that did occur were usually in the position vector, either using 8**i** +11**j** or else leaving it out completely. Also some candidates used a position vector for **v**. A few candidates found the speed or velocity. However for those who had an answer to part (a) most were successful in carrying it correctly forward into this part.

Part (c). Most knew they had to equate the position vectors but a number did not then go on to equate coefficients of **i** and **j**. Those that did were largely successful in getting the right values out. Others tried to solve the equation for by crossing out all the '*t*'s or all the '**i**'s and '**j**'s. Some tried to divide vectors whilst others just substituted in random values for t.

Part (d). Relatively few got full marks here. Most ,who got part (a) correct ,were able to get the first mark. Common errors seen were finding the position at t = 3 and then using Pythagoras, or else using **v** x *t*. Some candidates just stated that the vectors were the same. Many of those who did carry out the correct calculations either left it at that, without making a statement, or else declared that the velocities rather than the speeds were equal. There were a few instances where 6**i** + 2**j** was taken as the second speed, with no obvious connection to their previous work, using the fact that the speeds must be equal! A few also guessed λ in part (d) and then placed this value at the end of a page of incomprehensible working in part (c).

Question 8

In parts (a) and (b), most were able to make a reasonable attempt at two equations of motion, but there were errors in signs and solutions. This was not helped by the fact that *T* was asked for first rather than *a* and some candidates lost marks due to trying to solve for *T* first rather than the easier route of solving for a. A few attempted the whole system equation and these solutions were in general less successful than those who used two separate equations to start with. In the last part, too many candidates were unable to visualise the situation clearly and then deal with it in a methodical fashion. If they failed to find both the velocity of *A* on impact with the ground and the distance that it had travelled they were unable to progress any further. Only the more able students managed correct solutions. Of those that managed to progress in part (c), there were sign errors which caused problems. Many chose to split the motion of *B* into two parts and these were usually quite successful provided that the extra distance travelled by *B* in the upward direction was taken into account.

Statistics for M1 Practice Paper Silver Level S1

Qu	Max score	Modal score	Mean %	Mean score for students achieving grade: ALL	A*	A	B	C	D	E	U
1	5		88	4.40	4.89	4.72	4.56	4.25	3.93	3.54	2.56
2	6		78	4.70	5.85	5.63	5.15	4.61	3.95	3.12	1.83
3	8		74	5.90		6.82	5.80	5.20	4.68	3.86	3.05
4	8	8	73	5.83	7.46	7.24	6.66	6.08	5.24	3.95	1.90
5	10		74	7.38		9.21	7.89	6.48	4.45	2.88	1.24
6	7	7	62	4.33	6.32	5.81	4.62	3.58	2.61	1.84	0.85
7	14		58	8.17		12.33	9.21	6.99	5.01	3.32	1.57
8	17		49	8.27	14.25	12.53	9.03	6.61	4.41	2.69	0.97
	75		**65.31**	**48.98**	**38.77**	**64.29**	**52.92**	**43.80**	**34.28**	**25.20**	**13.97**