Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Silver Level S4

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 7 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
66	58	50	42	35	28

1. Particle P of mass m and particle Q of mass km are moving in opposite directions on a smooth horizontal plane when they collide directly. Immediately before the collision the speed of P is $5u$ and the speed of Q is u. Immediately after the collision the speed of each particle is halved and the direction of motion of each particle is reversed.

Find

(*a*) the value of k,

(3)

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

(3)

June 2015

2.

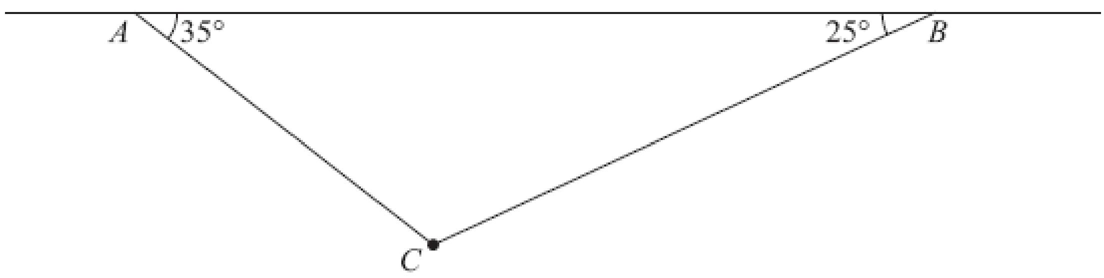


Figure 1

A particle of weight 8 N is attached at C to the ends of two light inextensible strings AC and BC. The other ends, A and B, are attached to a fixed horizontal ceiling. The particle hangs at rest in equilibrium, with the strings in a vertical plane. The string AC is inclined at 35° to the horizontal and the string BC is inclined at 25° to the horizontal, as shown in Figure 1.

Find

(i) the tension in the string AC,

(ii) the tension in the string BC.

(8)

May 2013 (R)

3.

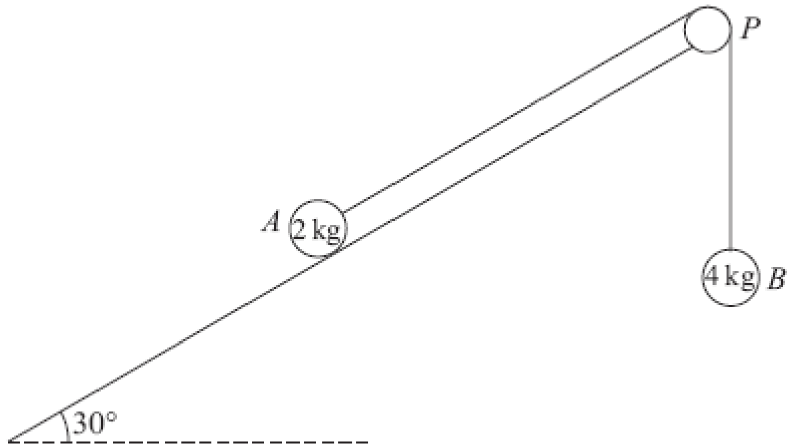


Figure 2

A fixed rough plane is inclined at 30° to the horizontal. A small smooth pulley P is fixed at the top of the plane. Two particles A and B, of mass 2 kg and 4 kg respectively, are attached to the ends of a light inextensible string which passes over the pulley P. The part of the string from A to P is parallel to a line of greatest slope of the plane and B hangs freely below P, as shown in Figure 2. The coefficient of friction between A and the plane is $\frac{1}{\sqrt{3}}$. Initially A is held at rest on the plane. The particles are released from rest with the string taut and A moves up the plane.

Find the tension in the string immediately after the particles are released.

(9)

May 2013 (R)

4.

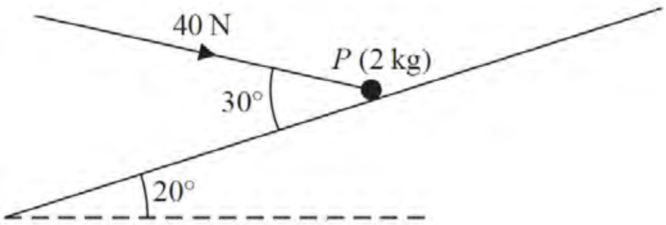


Figure 2

A particle P of mass 2 kg is held at rest in equilibrium on a rough plane by a constant force of magnitude 40 N. The direction of the force is inclined to the plane at an angle of 30°. The plane is inclined to the horizontal at an angle of 20°, as shown in Figure 2. The line of action of the force lies in the vertical plane containing P and a line of greatest slope of the plane. The coefficient of friction between P and the plane is μ.

Given that P is on the point of sliding up the plane, find the value of μ.

(10)

June 2016

5.

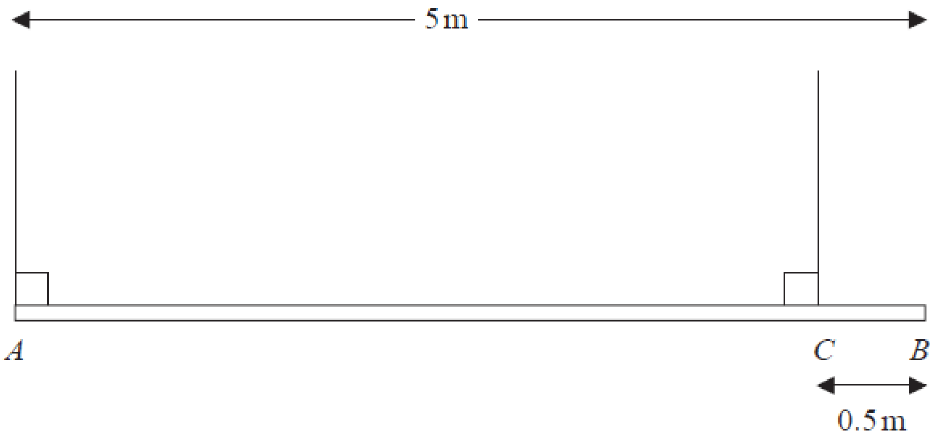


Figure 4

A beam *AB* has length 5 m and mass 25 kg. The beam is suspended in equilibrium in a horizontal position by two vertical ropes. One rope is attached to the beam at *A* and the other rope is attached to the point *C* on the beam where *CB* = 0.5 m, as shown in Figure 4. A particle *P* of mass 60 kg is attached to the beam at *B* and the beam remains in equilibrium in a horizontal position. The beam is modelled as a uniform rod and the ropes are modelled as light strings.

(*a*) Find

(i) the tension in the rope attached to the beam at *A*,

(ii) the tension in the rope attached to the beam at *C*.

(6)

Particle *P* is removed and replaced by a particle *Q* of mass *M* kg at *B*. Given that the beam remains in equilibrium in a horizontal position,

(*b*) find

(i) the greatest possible value of *M*,

(ii) the greatest possible tension in the rope attached to the beam at *C*.

(6)

June 2015

6. Two forces, $(4\mathbf{i} - 5\mathbf{j})$ N and $(p\mathbf{i} + q\mathbf{j})$ N, act on a particle P of mass m kg. The resultant of the two forces is $\mathbf{R}$. Given that $\mathbf{R}$ acts in a direction which is parallel to the vector $(\mathbf{i} - 2\mathbf{j})$,

(*a*) find the angle between $\mathbf{R}$ and the vector $\mathbf{j}$,

(3)

(*b*) show that $2p + q + 3 = 0$.

(4)

Given also that $q = 1$ and that P moves with an acceleration of magnitude $8\sqrt{5}$ m s^{-2},

(*c*) find the value of m.

(7)

January 2009

7.

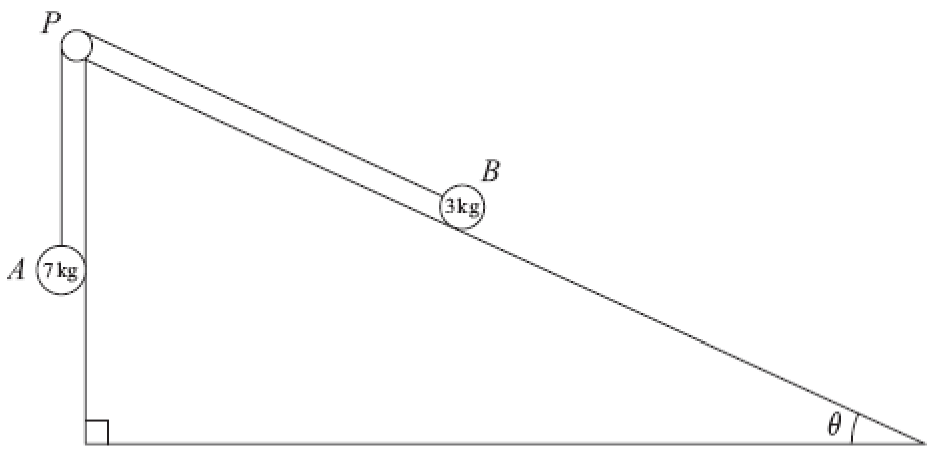


Figure 5

Two particles A and B, of mass 7 kg and 3 kg respectively, are attached to the ends of a light inextensible string. Initially B is held at rest on a rough fixed plane inclined at angle θ to the horizontal, where $\tan \theta = \frac{5}{12}$. The part of the string from B to P is parallel to a line of greatest slope of the plane. The string passes over a small smooth pulley, P, fixed at the top of the plane. The particle A hangs freely below P, as shown in Figure 5. The coefficient of friction between B and the plane is $\frac{2}{3}$. The particles are released from rest with the string taut and B moves up the plane.

(*a*) Find the magnitude of the acceleration of B immediately after release.

(10)

(*b*) Find the speed of B when it has moved 1 m up the plane.

(2)

When B has moved 1 m up the plane the string breaks. Given that in the subsequent motion B does not reach P,

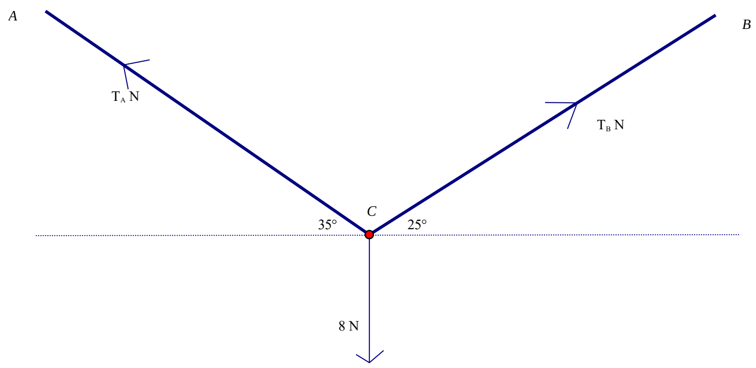
(*c*) find the time between the instants when the string breaks and when B comes to instantaneous rest.

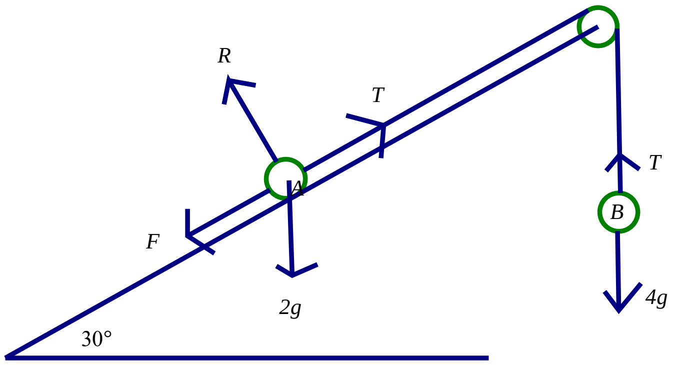
(4)

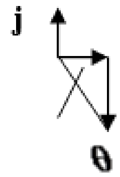
January 2011

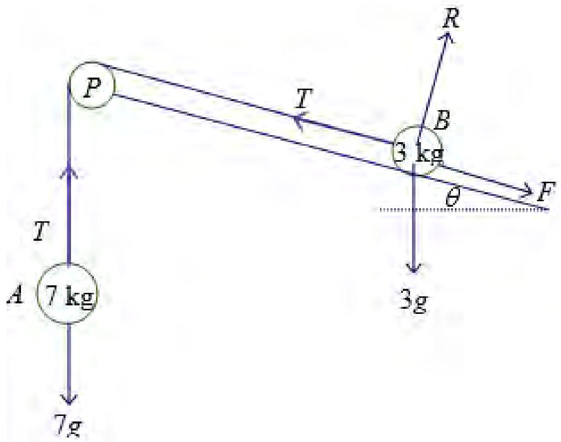
TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)	$m.5u - kmu = -\frac{m.5u}{2} + \frac{km.u}{2}$	M1 A1
	$k = 5$	A1
		(3)
(b)	For $P: I = m\left(\frac{5u}{2} - -5u\right)$ OR For $Q: I = km\left(\frac{u}{2} - -u\right)$	M1 A1
	$= \frac{15mu}{2}$ $= \frac{15mu}{2}$	A1
		(3)
		[6]
2		
	Resolve horizontally: $T_A \cos 35° = T_B \cos 25°$	M1A1
	Resolve vertically: $T_A \sin 35° + T_B \sin 25° = 8$	M1A1
	Equation in one unknown: $T_B \frac{\cos 25°}{\cos 35°} \sin 35° + T_B \sin 25° = 8$	**DM1**A1
	or $T_A \sin 35° + T_A \frac{\cos 35°}{\cos 25°} \sin 25° = 8$	
	T_A = 8.4, 8.37, 8.372 (N) or better	A1
	T_B = 7.6, 7.57, 7.567 (N) or better	A1
		[8]

Question number	Scheme	Marks
3		
	Equation of motion of B: $4g - T = 4a$	M1A1
	Equation of motion of A: $T - F - 2g\sin 30 = 2a$	M1A2
	OR: $4g - F - 2g\sin 30 = 6a$	
	Resolve perpendicular to the plane at A: $R = 2g\cos 30$	B1
	Use of $F = \mu R$: $F = \frac{1}{\sqrt{3}} \times 2g\cos 30 (= g)$	M1
	$T - g - g = T - 2g = 2a$	
	$2T - 4g = 4g - T$, $3T = 8g$, $T = \frac{8g}{3} (\approx 26)$ 26.1(N)	**DM1**A1
		[9]
4	μR	B1
	$R = 2g\cos 20^\circ + 40\cos 60^\circ$	M1 A2
	$F = 40\cos 30^\circ - 2g\cos 70^\circ$	M1 A2
	$\mu = \dfrac{40\cos 30^\circ - 2g\cos 70^\circ}{2g\cos 20^\circ + 40\cos 60^\circ}$	M1 M1
	$= 0.73$ or 0.727	A1
		[10]

Question number	Scheme	Marks
5 (a)	$T_A + T_C = 85g$ OR $M(A),\ 25g\square 2.5 + 60g\square 5 = 4.5\square T_C$ OR $M(C),\ T_A\square 4.5 + 60g\square 0.5 = 25g\square 2$ OR $M(B),\ T_A\square 5 + T_C\square 0.5 = 25g\square 2.5$ OR $M(G),\ T_A\square 2.5 + 60g\square 2.5 = 2\square T_C$ $T_A = \frac{40g}{9} = 44\text{N or } 43.6\text{N};\ T_C = \frac{725g}{9} = 790\text{N or } 789\text{ N}$	M1 A1 M1 A1 A1; A1 **(6)**
(b) **(i)**	$\text{M}(C),\ 25g\square 2 = Mg\square 0.5$ $M = 100$	M1 A1 A1
(ii)	$T_c = 25g + 100g$ $T_c = 125g\ (1200 \text{ or } 1230)\text{N}$	M1 A1 B1 **(6)** **[12]**
6 (a)	 $\tan\theta = \frac{2}{1} \Rightarrow \theta = 63.4^{\circ}$ angle is 153.4°	M1 A1 A1 **(3)**
(b)	$(4+p)\mathbf{i} + (q-5)\mathbf{j}$ $(q-5) = -2(4+p)$ $2p + q + 3 = 0$ *	B1 M1 A1 A1 **(4)**
(c)	$q = 1 \Rightarrow p = -2$ $\Rightarrow \mathbf{R} = 2\mathbf{i} - 4\mathbf{j}$ $\Rightarrow \lvert\mathbf{R}\rvert = \sqrt{2^2 + (-4)^2} = \sqrt{20}$ $\sqrt{20} = m8\sqrt{5}$ $\Rightarrow m = \frac{1}{4}$	B1 M1 M1 A1 f.t. M1 A1 f.t. A1 cao **(7)** **[14]**

Question number	Scheme	Marks
7 (a)	 $\tan\theta = \frac{5}{12}$ $\sin\theta = \frac{5}{13}$ $\cos\theta = \frac{12}{13}$	
	For A: $7g - T = 7a$	M1 A1
	For B: parallel to plane $T - F - 3g\sin\theta = 3a$	M1 A1
	perpendicular to plane $R = 3g\cos\theta$	M1 A1
	$F = \mu R = 3g\cos\theta = 2g\cos\theta$	M1
	Eliminating T, $7g - F - 3g\sin\theta = 10a$	DM1
	Equation in g and a: $7g - 2g\times\frac{12}{13} - 3g\frac{5}{13} = 7g - \frac{39}{13}g = 4g = 10a$	DM1
	$a = \frac{2g}{5}$ *oe* or 3.9 or 3.92	A1
		(10)
(b)	After 1 m,	
	$v^2 = u^2 + 2as$, $v^2 = 0 + 2\times\frac{2g}{5}\times 1$	M1
	$v = 2.8$	A1
		(2)
(c)	$-(F + 3g\ \sin\theta) = 3a$	M1
	$\frac{2}{3}\times 3g\times\frac{12}{13} + 3g\times\frac{5}{13} = 3g = -3a,\ a = -g$	A1
	$v = u + at$, $0 = 2.8 - 9.8t$,	DM1
	$t = \frac{2}{7}$ oe, 0.29. 0.286	A1
		(4)
		[16]

Examiner reports

Question 1

Overall this was a well-answered question and got the candidates off to a confident start. In the first part the vast majority of candidates was able to write a correct equation using Conservation of Linear Momentum and this led, for most, to the correct value for the unknown k. Errors tended to occur because of algebraic slips or, slightly more commonly, through careless cancelling in omitting to cancel elements from one of the terms. Too frequently 'u' was being dropped and replaced by its coefficient. At this level, it is to be hoped that candidates, when checking answers, would recognise that each term here should be of the same form and, if this was not the case, to do something to rectify the matter. Less popular was to equate the impulses on the two particles; the major disadvantage here is that errors in impulses are more common than with momentum and thus, the method gives candidates greater opportunity to make mistakes. In general, the CLM approach was done well and it may be that having two particles moving in opposite directions before and after the collision leaves less room for careless errors.

Part (b) was a very familiar follow-up to the first part with many reaching the correct answer quickly and efficiently. However a sizeable minority were unable to deal successfully with subtracting two momenta of different signs although it was evident that almost all knew that the two momenta had to be subtracted. If 'm's or 'u's were omitted or 'cancelled' the answer was not an impulse and all marks were lost. There was still a significant number who gave a magnitude as a negative quantity and lost the final mark.

Question 2

This question was usually done very well with the vast majority resolving horizontally and vertically. Some candidates lost one or both of the final A marks due to rounding errors while others made an error in solving their simultaneous equations. A very small number of candidates used the Sine Rule on a triangle of forces, a few resolved along the strings and one or two resolved perpendicular to the strings. Those that assumed that the two tensions were equal lost most of the marks.

Question 3

The vast majority had little difficulty with this question with the most common error being over specification of the final answer. Candidates should be reminded to round to an appropriate degree of accuracy when the numerical value of g (9.8) has been used to calculate an answer (see above). Most considered the two particles separately but occasionally a 'whole system' equation was seen and candidates are reminded that this approach is discouraged.

Question 4

The vast majority of candidates were able to resolve parallel and perpendicular to the plane to produce two correct equations but sin/cos confusion, sign errors or incorrect angles caused a few to lose marks. Some of the candidates attempted to resolve vertically and horizontally. The use of $F = \mu R$ was evident in nearly all responses and the mark scheme allowed the last two method marks which was a lifeline to those who had gone wrong yet knew they had to eliminate R and use F/R to obtain the answer. Almost all candidates rounded their answers correctly.

Question 5

In part (a) the vast majority of the cohort was able to score well on this very standard problem. Apart from the occasional minor arithmetical slips, most were able to produce a vertical resolution and to take moments about *A* or *C*. Those who took moments about *C* were at a slight disadvantage as there was a higher probability of a sign error in this situation. Most candidates were able to produce correct solutions for the tensions although once again, many lost a single mark through over-accuracy in a problem involving *g*, for giving answers to more than 3 significant figures. In the second part of the question many candidates failed to appreciate the significance of being asked to find the *greatest* possible values of *M* and *Tc*. Those who did analyse the situation successfully were able to gain easy marks but the sizeable majority went around and around in circles trying to deal with the problem of an extra variable. This type of problem emphasises the key importance of thinking clearly about the specific physical situation before embarking on the force diagram. Once again, the answer was obtained using *g* and a few candidates lost a mark for giving the answer to more than 3 significant figures.

Question 6

Many were able, in the first part, to use tan to find an acute angle, scoring two of the three marks, but were then unable to identify and find the required angle. In part (b), the first mark was for adding the two vectors together but many students then stated that this sum was equal to (**i** – 2**j**) rather than a multiple of it and were unable to make any progress. In the final part, many who failed in (b), obtained $p = -2$ from the printed equation and, even if their **R** was wrong, were able to benefit from follow-through marks. It was amazing to see so many arrive correctly at $\sqrt{20} = m8\sqrt{5}$ then correctly write $m = 2\sqrt{5} / 8\sqrt{5}$ but then give $m = 5/4$!

Question 7

Despite the lack of structure in part (a) most candidates knew the methods required. Many gained the marks for resolving perpendicular to the slope and for using $F = \frac{2}{3}R$. The equation of motion for the 7 kg mass was also often correct, but a common error was to replace *T* by 7*g* when resolving parallel to the plane. Sometimes a term, either friction or the weight component, was omitted from this equation. Although some candidates failed to complete successfully all the substitution and rearranging required to find the acceleration, there were a number of entirely correct solutions. An appropriate constant acceleration formula was generally used for the velocity in part (b), although an incorrect answer from part (a) led to loss of the accuracy mark. In the final part, many did not manage to find the new acceleration by a valid method; some used the value from part (a) or quoted '9.8' without any justification, whilst others realised that a new value was required but omitted a term from the equation of motion. Amongst those who resolved the two forces, a number had friction acting in the wrong direction. There were a small number of entirely correct solutions seen.

Statistics for M1 Practice Paper Silver Level S4

				Mean score for students achieving grade:							
Qu	**Max score**	**Modal score**	**Mean %**	**ALL**	**A***	**A**	**B**	**C**	**D**	**E**	**U**
1	6	6	84	5.02	5.78	5.61	5.29	5.01	4.67	4.15	2.71
2	8		72	5.74	7.49	7.12	5.80	4.67	2.91	3.37	1.56
3	9		75	6.73	8.30	7.98	7.09	5.74	4.21	3.79	1.72
4	10	10	89	8.86	9.85	9.70	9.34	8.92	8.41	7.39	4.91
5	12	7	60	7.17	10.12	9.05	7.46	6.59	5.69	4.53	2.36
6	14		39	5.51		9.08	4.46	3.05	2.20	1.57	0.64
7	16		57	9.10	13.71	12.27	8.75	6.10	4.17	2.87	0.99
	25		**64.17**	**48.13**	**55.25**	**60.81**	**48.19**	**40.08**	**32.26**	**27.67**	**14.89**