Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Gold Level G1

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
64	56	48	40	34	26

1. Particle P has mass 3 kg and particle Q has mass 2 kg. The particles are moving in opposite directions on a smooth horizontal plane when they collide directly. Immediately before the collision, P has speed 3 m s^{-1} and Q has speed 2 m s^{-1}. Immediately after the collision, both particles move in the same direction and the difference in their speeds is 1 m s^{-1}.

(*a*) Find the speed of each particle after the collision.

(5)

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

(3)

May 2011

2.

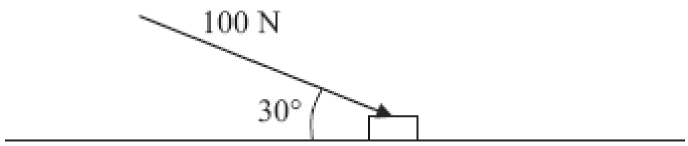

Figure 1

A small box is pushed along a floor. The floor is modelled as a rough horizontal plane and the box is modelled as a particle. The coefficient of friction between the box and the floor is $\frac{1}{2}$. The box is pushed by a force of magnitude 100 N which acts at an angle of 30° with the floor, as shown in Figure 1.

Given that the box moves with constant speed, find the mass of the box.

(7)

May 2010

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3. 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)

June 2014 (R)

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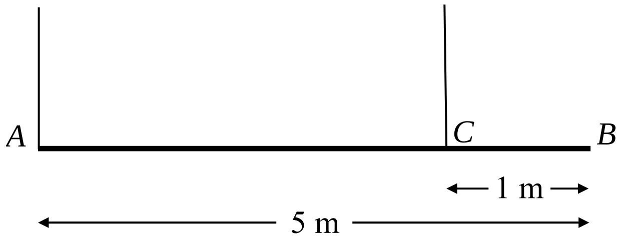
4. **Figure 2**



A beam AB has mass 12 kg and length 5 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. One rope is attached to A, the other to the point C on the beam, where BC = 1 m, as shown in Figure 2. The beam is modelled as a uniform rod, and the ropes as light strings.

(*a*) Find

(i) the tension in the rope at C,

(ii) the tension in the rope at A.

(5)

A small load of mass 16 kg is attached to the beam at a point which is y metres from A. The load is modelled as a particle. Given that the beam remains in equilibrium in a horizontal position,

(*b*) find, in terms of y, an expression for the tension in the rope at C.

(3)

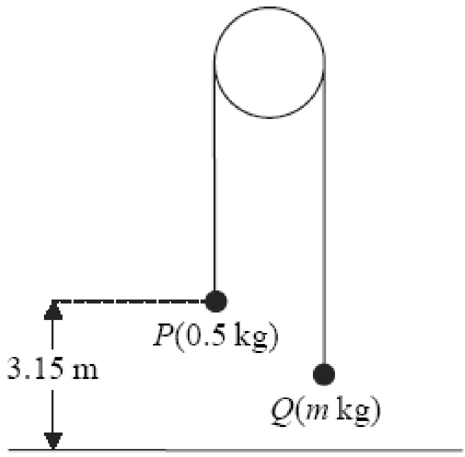
The rope at C will break if its tension exceeds 98 N. The rope at A cannot break.

(*c*) Find the range of possible positions on the beam where the load can be attached without the rope at C breaking.

(3)

January 2008

5. **Figure 3**



Two particles P and Q have mass 0.5 kg and m kg respectively, where $m < 0.5$. The particles are connected by a light inextensible string which passes over a smooth, fixed pulley. Initially P is 3.15 m above horizontal ground. The particles are released from rest with the string taut and the hanging parts of the string vertical, as shown in Figure 3. After P has been descending for 1.5 s, it strikes the ground. Particle P reaches the ground before Q has reached the pulley.

(*a*) Show that the acceleration of P as it descends is 2.8 m s^{-2}.

(3)

(*b*) Find the tension in the string as P descends.

(3)

(*c*) Show that $m = \frac{5}{18}$.

(4)

(*d*) State how you have used the information that the string is inextensible.

(1)

When P strikes the ground, P does not rebound and the string becomes slack. Particle Q then moves freely under gravity, without reaching the pulley, until the string becomes taut again.

(*e*) Find the time between the instant when P strikes the ground and the instant when the string becomes taut again.

(6)

June 2007

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

A particle P is moving with constant velocity $(-5\mathbf{i} + 8\mathbf{j})$ m s^{-1}. Find

(*a*) the speed of P,

(2)

(*b*) the direction of motion of P, giving your answer as a bearing.

(3)

At time $t = 0$, P is at the point A with position vector $(7\mathbf{i} - 10\mathbf{j})$ m relative to a fixed origin O. When $t = 3$ s, the velocity of P changes and it moves with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}, where u and v are constants. After a further 4 s, it passes through O and continues to move with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}.

(*c*) Find the values of u and v.

(5)

(*d*) Find the total time taken for P to move from A to a position which is due south of A.

(3)

January 2008

7.

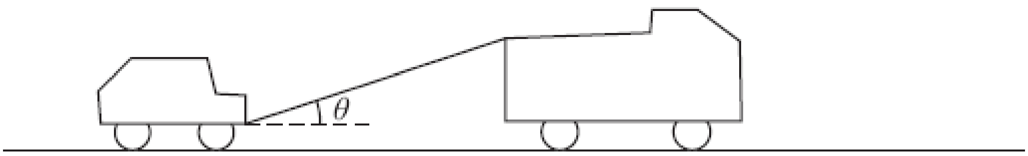


Figure 4

A truck of mass 1750 kg is towing a car of mass 750 kg along a straight horizontal road. The two vehicles are joined by a light towbar which is inclined at an angle θ to the road, as shown in Figure 4. The vehicles are travelling at 20 m s^{-1} as they enter a zone where the speed limit is 14 m s^{-1}. The truck's brakes are applied to give a constant braking force on the truck. The distance travelled between the instant when the brakes are applied and the instant when the speed of each vehicle is 14 m s^{-1} is 100 m.

(*a*) Find the deceleration of the truck and the car.

(3)

The constant braking force on the truck has magnitude R newtons. The truck and the car also experience constant resistances to motion of 500 N and 300 N respectively.

Given that $\cos\theta = 0.9$, find

(*b*) the force in the towbar,

(4)

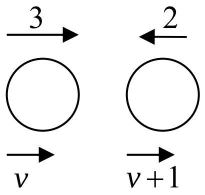
(*c*) the value of R.

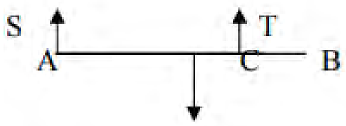
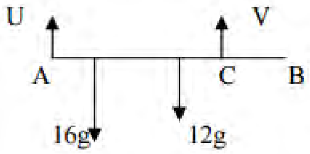
(4)

May 2013 (R)

TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)	 CLM: 3x3 - 2x2 = $3v + 2(v+1)$	M1 A1
	v_P= 0.6 m s^{-1}; v_Q= 1.6 m s^{-1}	M1A1 (A1 **ft)**
		(5)
(b)	$3(v-3)$ OR $2(v+1--2)$	M1 A1 **ft**
	= 7.2 Ns = 7.2 Ns	A1
		(3)
		[8]
2	(→) 100cos30 = F	M1 A1
	$F = 0.5\,R$ *seen*	A1 **(B1)**
	(↓) mg + 100cos60 = R	M1 A1
	m = 13 kg or 12.6 kg	**DM**1 A1
		[7]
3 (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)	$-3\times\dfrac{u^2}{2g} = ut - \dfrac{1}{2}gt^2$	M1
	$-3u^2 = 2ugt - g^2t^2$	
	$g^2t^2 - 2ugt - 3u^2 = 0,\quad gt = \dfrac{2u \pm \sqrt{4u^2+12u^2}}{2}$	**DM**1 A1
	$t = \dfrac{3u}{g} = 3T$	A1
		(4)
		[8]

Question number	Scheme	Marks
4 (a)		
	M(A): $T \times 4 = 12g \times 2.5$	M1 A1
	$T =$ <u>$7.5g$ or 73.5 N</u>	A1
	R(↑) $S + T = 12g$	M1
	$\Rightarrow S =$ <u>$4.5g$ or 44.1 N</u>	A1
		(5)
(b)		
	M(A) $V \times 4 = 16g \times y + 12g \times 2.5$	M1 A1
	$V =$ <u>$4gy + 7.5g$ or $39.2y + 73.5$ N</u>	A1
		(3)
(c)	$V \leq 98 \Rightarrow 39.2y + 73.5 \leq 98$	M1
	$\Rightarrow y \leq 0.625 = 5/8$	DM1
	Hence "load must be no more than 5/8 m from A" (o.e.)	A1
		(3)
		[11]

Question number	Scheme		Marks
5 (a)	$s = ut + \frac{1}{2}at^2 \quad \Rightarrow \quad 3.15 = \frac{1}{2}a \times \frac{9}{4}$		M1 A1
	$a = 2.8 \quad \left(\mathrm{m\,s^{-2}}\right)$ ∗	cso	A1
			(3)
(b)	N2L for P: $0.5g - T = 0.5 \times 2.8$		M1 A1
	$T = 3.5 \quad (\mathrm{N})$		A1
			(3)
(c)	N2L for Q: $T - mg = 2.8m$		M1 A1
	$m = \dfrac{3.5}{12.6} = \dfrac{5}{18}$ ∗	cso	DM1 A1
			(4)
(d)	The acceleration of P is equal to the acceleration of Q.		B1
			(1)
(e)	$v = u + at \quad \Rightarrow \quad v = 2.8 \times 1.5$		M1 A1
	(or $v^2 = u^2 + 2as \quad \Rightarrow \quad v^2 = 2 \times 2.8 \times 3.15$)		
	$\left(v^2 = 17.64, v = 4.2\right)$		
	$v = u + at \quad \Rightarrow \quad 4.2 = -4.2 + 9.8t$		DM1 A1
	$t = \dfrac{6}{7}$, 0.86, 0.857 (s)		DM1 A1
			(6)
			[17]

Question number	Scheme	Marks
6 (a)	Speed $= \sqrt{(5^2 + 8^2)} \approx \underline{9.43 \text{ m s}^{-1}}$	M1 A1 **(2)**
(b)	Forming arctan 8/5 or arctan 5/8 oe Bearing = 360 – arctan 5/8 or 270 + arctan 8/5 = $\underline{328}$	M1 DM1 A1 **(3)**
(c)	At $t = 3$, p.v. of P = $(7 - 15)\mathbf{i} + (-10 + 24)\mathbf{j} = -8\mathbf{i} + 14\mathbf{j}$ Hence $-8\mathbf{i} + 14\mathbf{j} + 4(u\mathbf{i} + v\,\mathbf{j}) = \mathbf{0}$ $\Rightarrow \underline{u = 2,\ \ v = -3.5}$	M1 A1 M1 DM1 A1 **(5)**
(d)	p.v. of P t secs after changing course = $(-8\mathbf{i} + 14\mathbf{j}) + t(2\mathbf{i} - 3.5\mathbf{j})$ $= 7\mathbf{i} + \ldots\ldots$ Hence total time = $\underline{10.5 \text{ s}}$	M1 DM1 A1 **(3)** **[13]**
7 (a)	Use of $v^2 = u^2 + 2as$ $14^2 = 20^2 - 2a \times 100$ Deceleration is 1.02(m s^{-2})	M1 A1 A1 **(3)**
(b)	Horizontal forces on the car: $\pm T\cos\theta - 300 = 750 \square -1.02 = -765$ $T = -1550/3$ The force in the tow-bar is 1550/3, 520 (N) or better (allow –ve answer)	M1A2 **f.t.** A1 **(4)**
(c)	Horizontal forces on the truck: $\pm T\cos\theta - 500 - R = 1750 \square -1.02$ Braking force $R =$ 1750 (N)	M1A2 **f.t.** A1 **(4)** **[11]**

Examiner reports

Question 1
In the first part, many candidates showed the velocities in the correct direction on a diagram but surprisingly many failed to realise that *Q* would be the faster particle. Most candidates could use the conservation of momentum principle to produce an equation of the form $3v_P + 2v_Q = (3\times3) \pm (2\times2)$, but fewer than half realised how to deal with the difference between the final speeds. Some had *P* travelling faster (1.4 and 0.4), others used *v* for *both* final speeds, found *v* = 1 then decided either that both were travelling at 1 m s^{-1} or that the speeds were 1 m s^{-1} and 2 m s^{-1} , either way round.

Part (b) was rather better done with most of those obtaining wrong answers in part (a) managing to score M1 A1ft A0. Only a few of those who had done part (a) correctly lost the final mark in part (b) for an answer of –7.2.

Question 2
Many candidates scored well on this question. Most resolved in the horizontal direction correctly, with the occasional introduction of an acceleration term at first. In most cases this was equated to zero and most candidates were able to score the method marks at least. The mark for use of limiting friction was obtained by most. For the vertical resolution, the most common errors were either for mistakes in sign or else to state that $R = mg$, omitting the component of the 100 N force. Very few candidates solved for the weight rather than the mass. Accuracy errors were common, with 12.57 being a common, too accurate, answer.

Question 3
Part (a) was generally well done and most were able to eventually find the given answer in the second part. However, the final part was much more challenging and confusion between *t* and *T* caused many of the problems.

Question 4
Apart from the minority of candidates who, in their moments equation, failed to multiply the tension by a length (dimensionally incorrect ⇒ no marks) or those who omitted g, part (a) was well-answered. In the second part a number of candidates failed to re-arrange their moments equation to give an expression for the tension and made *y* the subject instead.

Most proceeded, in the final part, via an equation rather than an inequality and very few made the final verbal statement referring specifically to the positioning of the load rather than a defined ‘*y*’.

Question 5

Part (a)

Many candidates seemed to expect that the first part of the question would require equations of motion for each particle. Once into relevant calculations, however, most candidates were very successful in obtaining 2.8 m s^{-2}. The majority of successful candidates attempted this part directly using $s = ut + \frac{1}{2}at^2$. Others used a two step approach using $v = u + at$ to give $v = 4.2$, followed by use of another *suvat* formula to get 2.8. A very few tried a verification method which did gain them maximum marks at this stage.

Part (b) Candidates generally formed an $F = ma$ equation with the majority obtaining the correct equation and getting T = 3.5N. However there was still a sizeable number who mistakenly wrote T- 0.5g = 0.5a =1.4. It is noticeable that despite regular comment from Edexcel some candidates still use g = 9.81 which leads to marks being lost in a variety of places where accuracy matters. *Part (c)* Many candidates formed a relevant equation, using the correct forces, reaching the stage of T = 3.5 = (2.8 + g) m and then went straight to m = 5/18, resulting in the loss of a mark. For many candidates there is still a lack of dexterity with the manipulation of fractions. Moreover, there is still a sizeable number of candidates who try to use one equation of motion for the whole system, despite advice to the contrary in several recent examiners reports.

Part (d) In this part, modelling was being tested and candidates needed to show that they really knew what was happening. A large number of candidates gave the correct answer that "both particles move with same acceleration" , gaining the single mark available. However candidates who tried to play safe and included another irrelevant reason, such as same tension, had not shown full understanding of the model and therefore were penalised. Other wrong answers included saying that acceleration was constant.

Part (e) Here, candidates first needed to find the speed of the system when the particle hit the ground. This required the calculation of v = 4.2 which some candidates merely quoted. This is the part of the question where candidates began to lose marks and common errors at this stage included using an incorrect value for acceleration. The question then continued with testing vertical motion under gravity. Successful candidates used a variety of equivalent methods. Some worked out the time to the top , followed by a calculation of distance followed by a calculation for time to fall back to launch point, followed by the addition of the two times, giving the answer to the correct degree of accuracy. Some took a more direct approach and used $s = ut + \frac{1}{2}at^2$ or $v = u + at$, for the whole of the remaining motion i.e. up and down. Many only found the time to the top and lost the final two marks. Common errors involved use of incorrect accelerations, displacements and times. Again candidates seem to want to work in decimals rather than in fractions. Candidates should be encouraged to make greater use of diagrams.

Question 6

In parts (a) and (b) most were able to find the speed of the particle and were also able to obtain an appropriate angle associated with it. Many were then unable to use this angle correctly to obtain the correct bearing.

There were a great many correct solutions for (c), but also many incorrect attempts. The majority of errors tended to come from those candidates who had not read the question carefully enough and did not incorporate the velocity vector (-5**i** + 12**j**) into their working or from those candidates making errors with directions. Many candidates were able to visualise the situation well, realising that 7**i** was involved, even though they may have made earlier errors in interpretation.

Question 7

This question provided some much needed discrimination. Part (a) was usually fine but some lost the final mark for giving a negative answer. In the second and third parts candidates were at least partially successful but it was very common to see sign errors in the equations of motion. Some who found T correctly in part (b) then forgot to resolve it in part (c). Another common error was to include R in the forces acting on the car and not on the truck.

Statistics for M1 Practice Paper Gold Level G1

				Mean score for students achieving grade:							
Qu	Max score	Modal score	Mean %	ALL	A*	A	B	C	D	E	U
1	8		62	4.92	6.65	6.31	5.29	4.67	3.90	3.20	1.81
2	7		70	4.90	6.66	6.30	5.54	4.76	3.87	2.88	1.40
3	8		69	5.53	7.19	6.17	5.04	5.00	4.60	3.45	2.29
4	11		63	6.98		9.45	7.77	5.36	3.90	2.15	1.34
5	17		61	10.37		14.52	11.87	9.51	7.20	5.12	2.20
6	13		57	7.39		9.48	6.59	4.95	4.03	3.18	2.26
7	11		55	6.09	8.79	7.62	5.69	4.71	3.59	3.64	2.30
	75		**61.57**	**46.18**	**29.29**	**59.85**	**47.79**	**38.96**	**31.09**	**23.62**	**13.60**