Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Bronze Level B5

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
71	64	57	50	44	37

1. Two particles A and B have masses 4 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 5 m s^{-1} and the speed of B is 3 m s^{-1}. Immediately after the collision, the direction of motion of A is unchanged and the speed of A is 1 m s^{-1}.

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

(2)

Immediately after the collision, the speed of B is 2 m s^{-1}.

(*b*) Find the value of m.

(4)

January 2008

2.

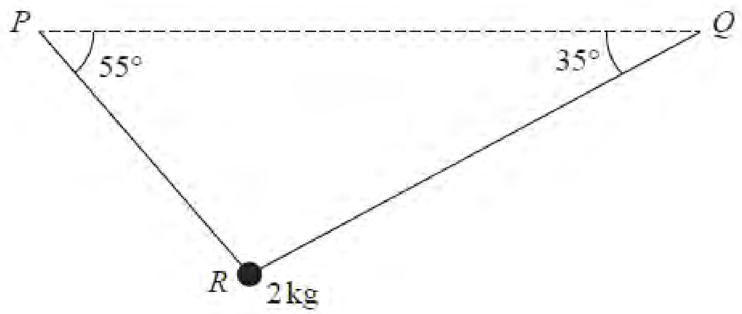


Figure 1

A particle of mass 2 kg is suspended from a horizontal ceiling by two light inextensible strings, PR and QR. The particle hangs at R in equilibrium, with the strings in a vertical plane. The string PR is inclined at 55° to the horizontal and the string QR is inclined at 35° to the horizontal, as shown in Figure 1.

Find

(i) the tension in the string PR,

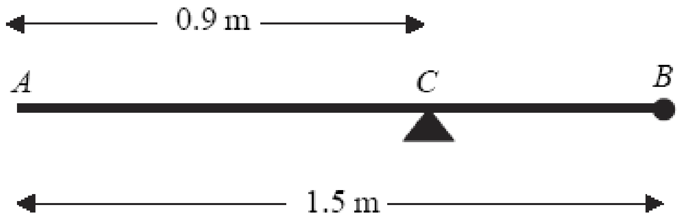
(ii) the tension in the string QR.

(7)

June 2015

---

3. **Figure 2**



A uniform rod AB has length 1.5 m and mass 8 kg. A particle of mass m kg is attached to the rod at B. The rod is supported at the point C, where AC = 0.9 m, and the system is in equilibrium with AB horizontal, as shown in Figure 2.

(*a*) Show that $m = 2$.

(4)

A particle of mass 5 kg is now attached to the rod at A and the support is moved from C to a point D of the rod. The system, including both particles, is again in equilibrium with AB horizontal.

(*b*) Find the distance AD.

(5)

June 2007

---

4. A girl runs a 400 m race in a time of 84 s. In a model of this race, it is assumed that, starting from rest, she moves with constant acceleration for 4 s, reaching a speed of 5 m s^{-1}. She maintains this speed for 60 s and then moves with constant deceleration for 20 s, crossing the finishing line with a speed of V m s^{-1}.

(*a*) Sketch a speed-time graph for the motion of the girl during the whole race.

(2)

(*b*) Find the distance run by the girl in the first 64 s of the race.

(3)

(*c*) Find the value of V.

(5)

(*d*) Find the deceleration of the girl in the final 20 s of her race.

(2)

May 2011

---

5. [*In this question, the unit vectors* **i** *and* **j** *are due east and due north respectively. Position vectors are relative to a fixed origin O.*]

A ship sets sail at 9 a.m. from a port P and moves with constant velocity. The position vector of P is $(4\mathbf{i} - 8\mathbf{j})$ km. At 9.30 a.m. the ship is at the point with position vector $(\mathbf{i} - 4\mathbf{j})$ km.

(*a*) Find the speed of the ship in km h^{-1}.

(4)

(*b*) Show that the position vector **r** km of the ship, t hours after 9 a.m., is given by

$$\mathbf{r} = (4 - 6t)\mathbf{i} + (8t - 8)\mathbf{j}.$$

(2)

At 10 a.m. a passenger on the ship observes that a lighthouse L is due west of the ship.
At 10.30 a.m. the passenger observes that L is now south-west of the ship.

(*c*) Find the position vector of L.

(5)

January 2013

6.

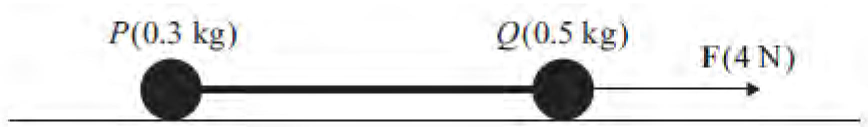


Figure 3

Two particles P and Q, of mass 0.3 kg and 0.5 kg respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane.

At time $t = 0$, a constant force **F** of magnitude 4 N is applied to Q in the direction PQ, as shown in Figure 3. The system moves under the action of this force until $t = 6$ s. During the motion, the resistance to the motion of P has constant magnitude 1 N and the resistance to the motion of Q has constant magnitude 2 N.

Find

(*a*) the acceleration of the particles as the system moves under the action of **F**,
(3)

(*b*) the speed of the particles at $t = 6$ s,
(2)

(*c*) the tension in the rod as the system moves under the action of **F**.
(3)

At $t = 6$ s, **F** is removed and the system decelerates to rest. The resistances to motion are unchanged. Find

(*d*) the distance moved by P as the system decelerates,
(4)

(*e*) the thrust in the rod as the system decelerates.
(3)

May 2012

7.

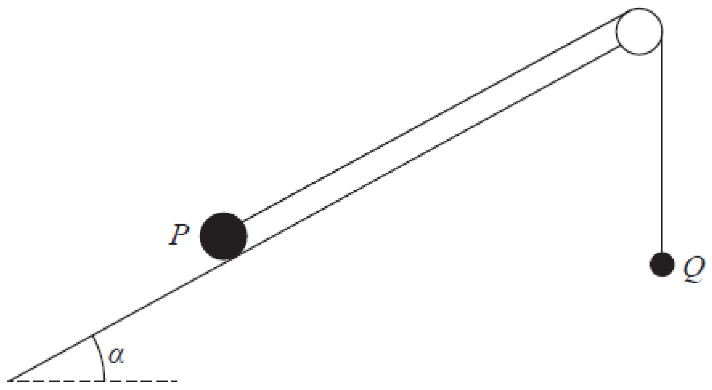


Figure 4

Two particles P and Q have mass 4 kg and 0.5 kg respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a fixed rough plane, which is inclined to the horizontal at an angle α where $\tan \alpha = \frac{4}{3}$. The coefficient of friction between P and the plane is 0.5. The string lies along the plane and passes over a small smooth light pulley which is fixed at the top of the plane. Particle Q hangs freely at rest vertically below the pulley. The string lies in the vertical plane which contains the pulley and a line of greatest slope of the inclined plane, as shown in Figure 4. Particle P is released from rest with the string taut and slides down the plane.

Given that Q has not hit the pulley, find

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

(11)

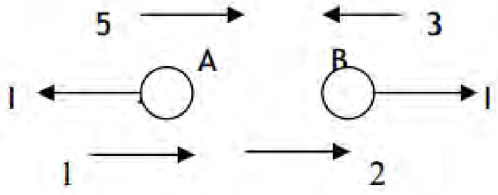
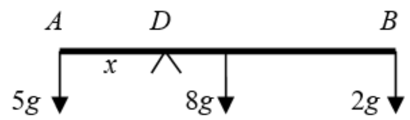
(b) the magnitude of the resultant force exerted by the string on the pulley.

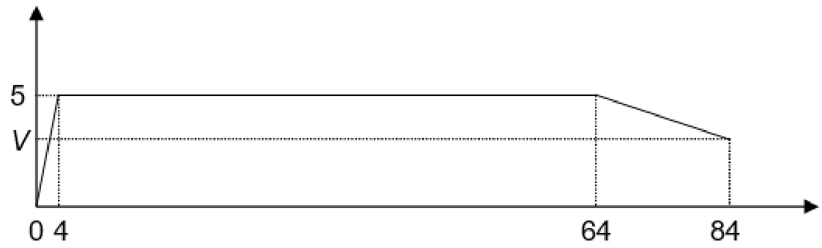
(4)

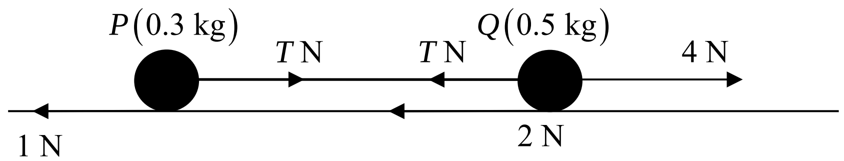
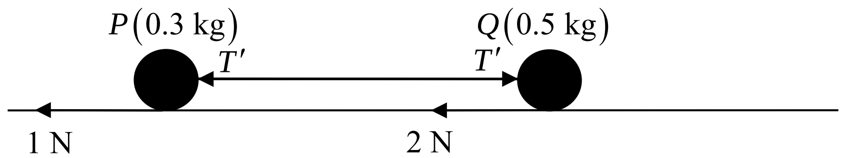
June 2015

TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)	 $I = 4(5-1) = \underline{16 \text{ Ns}}$	M1 A1 **(2)**
(b)	CLM: $4 \times 5 - m \times 3 = 4 \times 1 + m \times 2$ $\Rightarrow m = \underline{3.2}$ **or** $16 = m(3+2)$ $\Rightarrow m = \underline{3.2}$	M1 A1 DM1 A1 **or** M1 A1 DM1 A1 **(4)** **[6]**
2	$T_P \cos 55 = T_Q \cos 35$ $T_P \sin 55 + T_Q \sin 35 = 2g$ Eliminating T_P or T_Q $T_P = 16\text{N}$ or 16.1N; $T_Q = 11\text{N}$ or 11.2N	M1 A1 M1 A1 M1 A1 A1 **[7]**
3 (a)	M(C) $8g \times (0.9 - 0.75) = mg(1.5 - 0.9)$ Solving to $m = 2$ * cso	M1 A1 DM1 A1 **(4)**
(b)	 M(D) $5g \times x = 8g \times (0.75 - x) + 2g(1.5 - x)$ Solving to $x = 0.6$ ($AD = 0.6$ m)	M1 A2(1, 0) DM1 A1 **(5)** **[9]**

Question number	Scheme	Marks
4 (a)		B1 shape B1 figs **(2)**
(b)	$(\frac{1}{2}\text{x}4\text{x}5) + 60 \text{ x } 5$ $= 310$	M1 A1 A1 **(3)**
(c)	$\frac{(5+V)}{2} \text{ x } 20 = (400\text{-}310)$ $V = 4$	M1 A2 **ft** **DM**1 A1 **(5)**
(d)	$\frac{5-4}{20} = 0.05 \text{ ms}^{-2}$	M1 A1 **(2)** **[12]**
5 (a)	$\frac{(\mathbf{i} - 4\mathbf{j}) - (4\mathbf{i} - 8\mathbf{j})}{0.5}; (\pm 6\mathbf{i} \pm 8\mathbf{j})$ $\sqrt{(\pm 6)^2 + (\pm 8)^2} = 10$	M1 A1 M1 A1 **(4)**
(b)	$\mathbf{r} = (4\mathbf{i} - 8\mathbf{j}) + t(-6\mathbf{i} + 8\mathbf{j})$ $= (4\mathbf{i} - 8\mathbf{j}) - 6t\mathbf{i} + 8t\mathbf{j}$ $= (4 - 6t)\mathbf{i} + (8t - 8)\mathbf{j}$ *	M1 A1 **(2)**
(c)	At 10 am, $\mathbf{r} = -2\mathbf{i}$ At 10.30 am, $\mathbf{r} = -5\mathbf{i} + 4\mathbf{j}$ $\mathbf{l} = k\mathbf{i},\ k < -2$ $k = -5 - 4 = -9$ $\mathbf{l} = -9\mathbf{i}$	M1 A1 A1 DM1 A1 **(5)** **[11]**

Question number	Scheme	Marks
6 (a)		
	For system N2L $4-3=0.8a$	M1 A1
	$a=1.25\ (\text{m s}^{-2})$, 1.3	A1
		(3)
(b)	$v=u+at \Rightarrow v=0+1.25\times6=7.5\ (\text{m s}^{-1})$	M1 A1
		(2)
(c)	For P N2L $T-1=0.3\times1.25$ ft their a	M1 A1ft
	$T=1.375\ (\text{N})$ 1.38, 1.4	A1
	OR For Q N2L 4 - $2-T=0.5$ x 1.25	**(3)**
		
(d)	For system N2L $-3=0.8a \Rightarrow a=-3.75$	M1 A1
	$v^2=u^2+2as \Rightarrow 0^2=7.5^2-2\times3.75s$	M1
	$s=7.5\ (\text{m})$	A1
		(4)
(e)	For P N2L $T'+1=0.3\times3.75$	M1 A1
	$T'=0.125\ (\text{N})$, 0.13	A1
		(3)
		[15]

Question number	Scheme	Marks
7 (a)	$R = 4g\cos\alpha$	M1 A1
	$T - 0.5g = 0.5a$	M1 A1
	$4g\sin\alpha - T - F = 4a$	M1 A1
	(OR: $4g\sin\alpha - F - 0.5g = 4.5a$)	
	$F = \frac{1}{2}R$; $\sin\alpha = \frac{4}{5}$ or $\cos\alpha = \frac{3}{5}$	B1; B1
	Eliminating a or finding a	M1
	Solving for T (must have had an a)	M1
	$T = \frac{2g}{3}$ N or 6.5N or 6.53N	A1
		(11)
(b)	Magnitude $= 2T\cos\left(\frac{90-\alpha}{2}\right)$	M1 A1
	$= 2 \times \frac{2g}{3} \times \frac{3}{\sqrt{10}}$ (0.94868..)	A1 ft on T
	$= 12N$ or $12.4N$ $\left(\frac{4g}{\sqrt{10}}\right)$	A1
		(4)
		[15]

Examiner reports

Question 1

A good starter question enabling most candidates to obtain marks. A significant number of candidates gave an answer of -16 in part (a) rather than giving the magnitude of the impulse and lost a mark.

In part (b) 16 was a common incorrect answer resulting from an incorrect direction of motion for particle *B* i.e. $4 \times 5 - m \times 3 = 4 \times 1 - m \times 2$. A few candidates seemed unconcerned with a negative mass obtained from using ($+ m \times 3$) on the L.H.S. and there were also a few instances of candidates quoting and using the "formula" $m_1u_1 + m_1v_1 = m_2u_2 + m_2v_2$. It was rare to see correct solutions using Impulse and many included g in their Impulse-Momentum equation.

Question 2

For the most part candidates gained the method marks for this question, although the accuracy marks were often lost. The most popular approach was the main mark scheme method and in spite of some odd decisions to label the strings the wrong way round most were able to get the resolving correct. This method did involve the most difficult manipulation and many managed to drop trigonometric terms, leading to two incorrect answers. The most common error in eliminating one of the tensions appeared to be forgetting to multiply by the correct trigonometric ratio when substituting; for example $P = Q\dfrac{\cos 35}{\cos 55}$ was substituted into $P \sin 55 + Q \sin 35 = 2g$, but then sin 55 was forgotten, giving $Q\dfrac{\cos 35}{\cos 55} + Q \sin 35 = 2g$. Sadly too many who did get to the correct answers then gave too many significant figures and lost a mark. When attempting the alternative methods it tended to be all or nothing (apart from over accuracy). Resolving along the strings was reasonably popular and the trigonometry was nearly always the correct way round. All examples attempting to use either the sine rule or Lami's theorem tended to be correct.

Those who noticed that there was a right-angle involved were able to gain all 7 marks in just two lines of work by resolving along each string and were very clear and concise in their work. It was rare to find candidates assuming the tensions to be the same.

Question 3

Part (a). Most candidates answered this correctly, usually taking moments about *C*, although a small minority took moments about *A* or *D* having first ascertained the normal reaction at *C*.

Part (b). Candidates were less successful with this part. The successful answers usually took moments about *D* which they placed to the left of the centre of mass and called the distance *AD* '*x*'. This method obviated the need to find the normal reaction at *D*. Among those others who were also successful, the majority took moments about *A* having ascertained the normal reaction at *D* and again calling *AD* '*x*'. Some candidates created three unknowns: *AD*, *DC* and *DB*; these candidates were rarely successful in their answers, succumbing to the difficulty of unravelling a complexity of their own making. Other candidates failed for various reasons: some for incorrectly calculating the normal because they missed out the mass of the rod or one of the other masses, more usually the former, others because when they took moments about *D* they failed to take account of the mass of the rod, more usually, or one of the other masses. Some candidates were unsuccessful because they placed *D* on the right of the centre of mass and then ran into problems using $(7.5 - x)$ rather than $(x - 7.5)$.

Question 4

Almost all candidates scored full marks for part (a), with a few extending their graph beyond the line t = 84 and a very small minority leaving out V. Similarly the vast majority also obtained full marks in part (b). In the third part a significant number of candidates wrote down $\frac{1}{2}(5-v)20 = 90$. Sometimes it was clear that this was an attempt at finding the area of a trapezium, sometimes it was clearly the area of a triangle (occasionally accompanied by a helpful explanatory diagram) and sometimes one could not be sure. Occasionally one suspected that it was an application of the most commonly used wrong *suvat* formula $s = \frac{1}{2}(v-u)t$.

In the final part, virtually all candidates subtracted the relevant velocities and divided by the time to find the deceleration; those who found the velocity erroneously in part (c) could not achieve the final accuracy mark. This mark also required a positive value for the deceleration.

Question 5

Apart from the final two available marks, this vector question was generally well answered. In part (a) most candidates could derive the relevant velocity from the given position vectors and time. However, some failed to realise that 'speed' required evaluation of the magnitude of their vector. In the second part the required expression for the general position vector was given, and so it was essential that the derivation was clear and entirely correct, including "**r** = ". An incorrect velocity vector from part (a) correctly used here earned one of the two available marks. However, if the working was not consistent with that in part (a), both marks were lost unless there was clear evidence of the velocity being re-calculated. In part (c) many candidates substituted the relevant values of t (1 and 1.5) into the given expression to find the position vectors at these times. However, only a minority used these properly to solve the problem. Some realised that the **j**-component of the position vector of L was zero, but deduced that the **i**-component was –8**i** or –7**i** rather than the correct value –9**i**. A clear diagram would have helped many to fully appreciate the situation.

Question 6

As is usually the case with questions of this type, better candidates who understood the principles scored well and there were a significant number of fully correct answers. Better candidates benefited from appreciating that Newton's Law needed to be applied to either the whole system or to a single particle. The nature of these questions is that errors often involve missing or extra forces and this causes a significant loss of marks. The *suvat* parts were done quite well although a number of candidates tried to use the information about t or T from parts (b) and (c), in part (d) and this usually caused major difficulties.

The majority of candidates answered part (a) correctly, usually by considering the whole system, but sometimes by considering the particles separately and eliminating T. Candidates who considered just one particle, by omitting T, rarely achieved success in any subsequent part of the question (although they usually picked up the M1 in part (b)). The vast majority answered the second part correctly. In part (c) most candidates were able to produce an equation of motion for one of the particles and those who scored full marks in part (a), generally scored full marks in parts (b) and (c) also. There was a minority, however, who appeared to have no idea how to cope with the particles separately; these candidates might score highly in parts (a), (b), and even in part (d), but they seemed stumped when they couldn't use 0.8 as the relevant mass i.e. in parts (c) and (e). In part (d) a new acceleration was needed and many candidates calculated it correctly then used it appropriately to find the distance travelled. A variety of errors appeared here. Some candidates used the old acceleration, others used g, some used just one particle and left out the thrust while others kept the 4N force. Others didn't think they needed an acceleration because they used t = 6 and

$s = \frac{t(u+v)}{2}$. Part (e) caused the most difficulty and a number of candidates were put off by the unfamiliar concept of a thrust**.**

Question 7

This was an unstructured question but a fairly familiar scenario. It involved setting up equations of motion (one vertical and one parallel to the inclined plane) for the two particles and then solving them (by eliminating or finding the acceleration) to find the value of the tension. Most candidates gained marks for correctly calculating the normal reaction and using this to find the frictional force. The most common error was in the sign of the friction term in the ‘parallel’ equation, possibly a result of misinterpretation of direction of motion. There were some instances of omitting a force term completely, sin/cos confusion or including ‘g’ in the ‘ma’ term. Occasionally the acceleration was not taken into account at all which led to oversimplification of the problem and consequently a significant loss of marks. 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 ‘$\frac{2}{3}g$’. 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, although the required angle was not always identified correctly with some using $2T \cos \frac{\pi}{2}$, or even $2T \cos 45$. The use of the cosine rule was an alternative method but again sometimes the wrong angle was used. Those who found a component only in either the horizontal or the vertical direction received no credit; however, those who proceeded to square and add both the components tended to do so correctly and achieve full marks. If an incorrect value for the tension was carried forward from part (a), three out of the possible four marks were available.

Statistics for M1 Practice Paper Bronze Level B5

Qu	Max score	Modal score	Mean %	ALL	A*	A	B	C	D	E	U
				Mean score for students achieving grade:							
1	6		84	5.04		5.62	5.21	5.06	4.32	3.89	2.82
2	7	7	74	5.21	6.64	6.33	5.67	4.94	4.17	3.31	2.04
3	9		75	6.74		8.57	7.87	6.92	5.72	4.22	1.89
4	12		79	9.43	11.52	11.20	10.23	9.28	8.29	7.03	4.60
5	11	9	68	7.43	10.18	9.08	7.54	6.16	4.91	3.43	2.08
6	15		62	9.27	13.92	12.88	10.31	8.26	6.19	4.29	2.06
7	15	11	63	9.39	12.94	11.78	9.89	8.61	7.01	5.54	2.89
	75		**70.01**	**52.51**	**55.20**	**65.46**	**56.72**	**49.23**	**40.61**	**31.71**	**18.38**