Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Gold Level G5

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
52	45	36	29	22	16

1. Three posts P, Q and R, are fixed in that order at the side of a straight horizontal road. The distance from P to Q is 45 m and the distance from Q to R is 120 m. A car is moving along the road with constant acceleration a m s^{-2}. The speed of the car, as it passes P, is u m s^{-1}. The car passes Q two seconds after passing P, and the car passes R four seconds after passing Q.

Find

(i) the value of u,

(ii) the value of a.

(7)

May 2009

---

2. A particle is acted upon by two forces $\mathbf{F}_1$ and $\mathbf{F}_2$, given by

$\mathbf{F}_1 = (\mathbf{i} - 3\mathbf{j})$ N,

$\mathbf{F}_2 = (p\mathbf{i} + 2p\mathbf{j})$ N, where p is a positive constant.

(*a*) Find the angle between $\mathbf{F}_2$ and $\mathbf{j}$.

(2)

The resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ is $\mathbf{R}$. Given that $\mathbf{R}$ is parallel to $\mathbf{i}$,

(*b*) find the value of p.

(4)

May 2009

---

3. Two particles A and B are moving on a smooth horizontal plane. The mass of A is $2m$ and the mass of B is m. The particles are moving along the same straight line but in opposite directions and they collide directly. Immediately before they collide the speed of A is $2u$ and the speed of B is $3u$. The magnitude of the impulse received by each particle in the collision is $\frac{7mu}{2}$.

Find

(*a*) the speed of A immediately after the collision,

(3)

(*b*) the speed of B immediately after the collision.

(3)

May 2009

4.

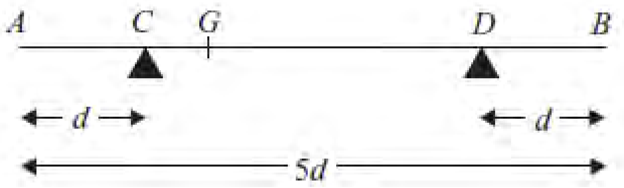


Figure 1

A non-uniform rod AB, of mass m and length $5d$, rests horizontally in equilibrium on two supports at C and D, where $AC = DB = d$, as shown in Figure 1. The centre of mass of the rod is at the point G. A particle of mass $\frac{5}{2}m$ is placed on the rod at B and the rod is on the point of tipping about D.

(*a*) Show that $GD = \frac{5}{2}d$.

(4)

The particle is moved from B to the mid-point of the rod and the rod remains in equilibrium.

(*b*) Find the magnitude of the normal reaction between the support at D and the rod.

(5)

January 2012

5.

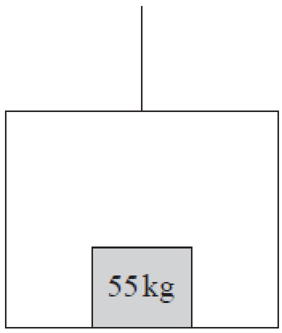


Figure 2

A lift of mass 200 kg is being lowered into a mineshaft by a vertical cable attached to the top of the lift. A crate of mass 55 kg is on the floor inside the lift, as shown in Figure 2. The lift descends vertically with constant acceleration. There is a constant upwards resistance of magnitude 150 N on the lift. The crate experiences a constant normal reaction of magnitude 473 N from the floor of the lift.

(*a*) Find the acceleration of the lift.

(3)

(*b*) Find the magnitude of the force exerted on the lift by the cable.

(4)

June 2015

6.

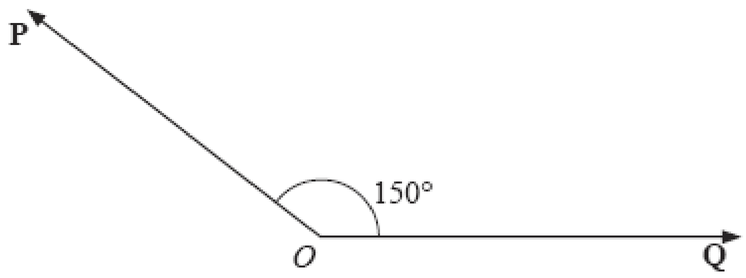


Figure 3

Two forces **P** and **Q** act on a particle at a point O. The force **P** has magnitude 15 N and the force **Q** has magnitude X newtons. The angle between **P** and **Q** is 150°, as shown in Figure 3. The resultant of **P** and **Q** is **R**.

Given that the angle between **R** and **Q** is 50°, find

(*a*) the magnitude of **R**,

(4)

(*b*) the value of X.

(5)

May 2008

7.

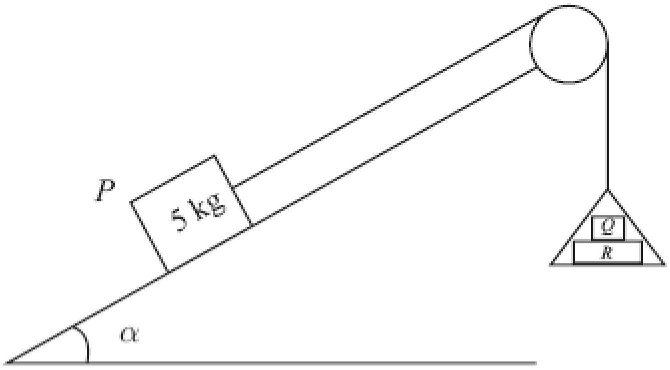


Figure 4

One end of a light inextensible string is attached to a block P of mass 5 kg. The block P is held at rest on a smooth fixed plane which is inclined to the horizontal at an angle α, where $\sin \alpha = \frac{3}{5}$. The string lies along a line of greatest slope of the plane and passes over a smooth light pulley which is fixed at the top of the plane. The other end of the string is attached to a light scale pan which carries two blocks Q and R, with block Q on top of block R, as shown in Figure 4. The mass of block Q is 5 kg and the mass of block R is 10 kg. The scale pan hangs at rest and the system is released from rest. By modelling the blocks as particles, ignoring air resistance and assuming the motion is uninterrupted, find

(*a*) (i) the acceleration of the scale pan,

(ii) the tension in the string,

(8)

(*b*) the magnitude of the force exerted on block Q by block R,

(3)

(*c*) the magnitude of the force exerted on the pulley by the string.

(5)

January 2009

8.

Figure 5

Two particles P and Q, of mass 2 kg and 3 kg respectively, are joined by a light inextensible string. Initially the particles are at rest on a rough horizontal plane with the string taut. A constant force **F** of magnitude 30 N is applied to Q in the direction PQ, as shown in Figure 5. The force is applied for 3 s and during this time Q travels a distance of 6 m. The coefficient of friction between each particle and the plane is μ. Find

(*a*) the acceleration of Q,

(2)

(*b*) the value of μ,

(4)

(*c*) the tension in the string.

(4)

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

(1)

When the particles have moved for 3 s, the force **F** is removed.

(*e*) Find the time between the instant that the force is removed and the instant that Q comes to rest.

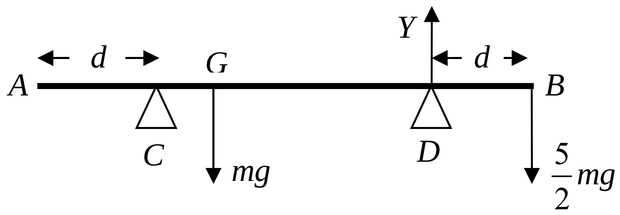
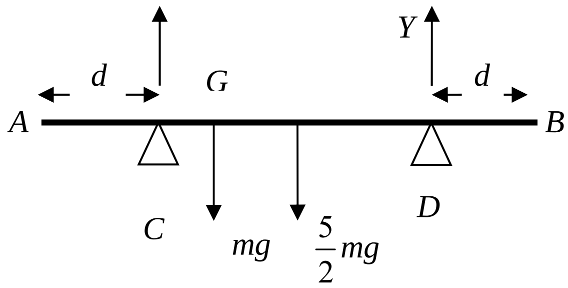
(4)

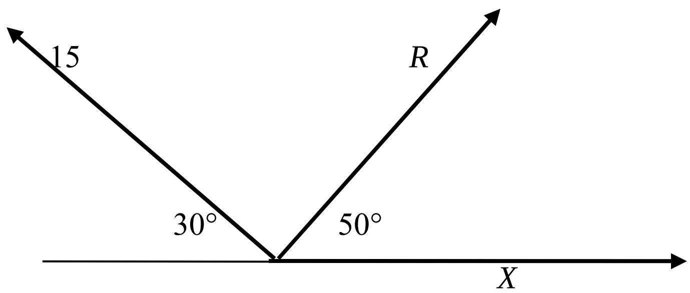
May 2008

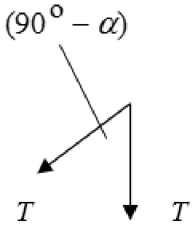
TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1	$45 = 2u + \frac{1}{2}a2^2 \quad \Rightarrow \quad 45 = 2u + 2a$	M1 A1
	$165 = 6u + \frac{1}{2}a6^2 \quad \Rightarrow \quad 165 = 6u + 18a$	M1 A1
	eliminating either u or a	M1
	$u = 20$ and $a = 2.5$	A1 A1
		[7]
2 (a)	$\tan\theta = \frac{p}{2p} \Rightarrow \theta = 26.6°$	M1 A1
		(2)
(b)	$\mathbf{R} = (\mathbf{i} - 3\mathbf{j}) + (p\mathbf{i} + 2p\mathbf{j}) = (1 + p)\mathbf{i} + (-3 + 2p)\mathbf{j}$	M1 A1
	$\mathbf{R}$ is parallel to $\mathbf{i} \quad \Rightarrow \quad (-3 + 2p) = 0$	DM1
	$\Rightarrow p = \frac{3}{2}$	A1
		(4)
		[6]
3 (a)	For A: $\quad -\dfrac{7mu}{2} = 2m(v_A - 2u)$	M1 A1
	$v_A = \dfrac{u}{4}$	A1
		(3)
(b)	For B: $\quad \dfrac{7mu}{2} = m(v_B - -3u)$	M1 A1
	$v_B = \dfrac{u}{2}$	A1
		(3)
		[6]

Question number	Scheme	Marks
4 (a)		
	M(D) $mg \times GD = \frac{5}{2}mg \times d$	M1 A1
	$GD = \frac{5}{2}d$ *	DM1 A1
		(4)
(b)		
	M(C) $mg \times \frac{d}{2} + \frac{5}{2}mg \times \frac{3}{2}d = Y \times 3d$	M1 A2(1, 0)
	Leading to $Y = \frac{17}{12}mg$	DM1 A1
		(5)
		[9]

Question number	Scheme	Marks
5 (a)	For crate, $55g - 473 = 55a$	M1 A1
	$a = 1.2\text{m s}^{-2}$	A1
		(3)
(b)	For system, $55g + 200g \pm T - 150 = 255a$	M1 A2
	M agnitude $= 2040$ N or 2000 N	A1
	OR	
	For lift, $200g + 473 - 150 \pm T = 200a$	
	M agnitude $= 2040$ N or 2000 N	M1 A2
		A1
		(4)
		[7]
6 (a)		
	$(\uparrow)$ $15\sin 30° = R\sin 50°$	M1 A1
	$R \approx 9.79$ (N)	M1 A1
		(4)
(b)	$(\rightarrow)$ $X - 15\cos 30° = R\cos 50°$ ft their R	M1 A2 ft
	$X \approx 19.3$ (N)	M1 A1
		(5)
		[9]

Question number	Scheme	Marks
7 (a)	$T - 5g\sin\alpha = 5a$	M1 A1
	$15g - T = 15a$	M1 A1
	solving for a	M1
	$a = 0.6g$	A1
	solving for T	M1
	$T = 6g$	A1
		(8)
(b)	For Q : $5g - N = 5a$	M1 A1
	$N = 2g$	A1 f.t.
		(3)
(c)	 $F = 2T\cos(\frac{90^\circ - \alpha}{2})$	M1 A2
	$= 12g\cos 26.56..^\circ$	A1 f.t.
	$= 105$ N	A1
		(5)
		[16]

Question number	Scheme	Marks
8 (a)	T T 30	
	$\mu 2g$ $\mu 3g$	
	$s = ut + \frac{1}{2}at^2 \Rightarrow 6 = \frac{1}{2}a \times 9$	M1
	$a = 1\frac{1}{3}$ $\left(\text{ms}^{-2}\right)$	A1
		(2)
(b)	N2L for system $30 - \mu 5g = 5a$ ft their a, accept symbol	M1 A1ft
	$\mu = \frac{14}{3g} = \frac{10}{21}$ or awrt 0.48	M1 A1
		(4)
(c)	N2L for P $T - \mu 2g = 2a$ ft their μ, their a, accept symbols	M1 A1 ft
	$T - \frac{14}{3g} \times 2g = 2 \times \frac{4}{3}$	
	Leading to $T = 12$ (N) awrt 12	M1 A1
		(4)
(d)	The acceleration of P and Q (or the whole of the system) is the same.	B1
		(1)
(e)	$v = u + at \Rightarrow v = \frac{4}{3} \times 3 = 4$	B1 ft on a
	N2L (for system or either particle)	
	$-5\mu g = 5a$ or equivalent	M1
	$a = -\mu g$	
	$v = u + at \Rightarrow 0 = 4 - \mu g t$	M1
	Leading to $t = \frac{6}{7}$ (s) accept 0.86, 0.857	A1
		(4)
		[15]

Examiner reports

Question 1

This was a more difficult question 1 than usual, in that neither u nor a could be found directly from the given information and it was necessary to set up a pair of simultaneous equations. Many were able to write down an equation for the motion from P to Q but then struggled to find another one. By far the most common error was to say that the average velocity over an interval was equal to the actual velocity at one end of it. Those candidates who produced two correct equations invariably produced the correct answers. A few candidates found the acceleration but then forgot to find the value of u.

Question 2

In part (a) the majority of candidates were able to find the correct angle. For those that didn't the most common error was to find the complementary angle. In the second part, provided that it was realised that the sum of the **j** components was equal to zero, full marks were usually achieved. A significant number of candidates equated the sum of the **i** components to zero.

Question 3

Impulses continue to cause problems and a correct solution to part (a) was rarely seen. Most candidates know that impulse = change in momentum but few can cope with the signs correctly and the impulse in the first part almost always had the wrong sign. The second part produced more success and if the impulse-momentum principle was used again, this part was independent of part (a) and so full marks could be scored. Some tried to use the conservation of momentum principle in part (b), but this relied on using their possibly incorrect answer to part (a).

Question 4

Part (a) was answered well by the majority, with most taking moments about D. Consistent omission of g's was allowed since they cancelled out. A few candidates failed to mention GD at all, using an unknown x as the length required, and these were penalised. A few got themselves in a mess by failing to realise that the reaction at C was zero, and although it was still possible to solve the problem, few were able to write down two correct equations and then eliminate the reaction at C successfully to obtain GD. The second part was attempted by almost all candidates with the most common error being the omission of g from one or more terms of their moment's equation. Lengths were generally correct for most of those who attempted this question and it was pleasing to see that nearly all the candidates realised that the rod was non-uniform.

Question 5

This question proved to be a real discriminator with many failing to appreciate how internal and external forces work, it was not unusual for candidates to produce incorrect equations and score zero marks for the whole question. Future candidates would be advised to spend time analysing lift systems and practising writing down the equations of motion for each part of the system. In part (a), the motion of the lift was attributed with two unknown quantities and hence the first part of the question could only be done in one stage by considering the forces acting on the crate. Candidates able to arrive at the correct value for the acceleration were very much in the minority. The second part could be done without using the answer to part (a), and most successful attempts came from using a whole system equation. Those who used an equation for the lift only, tended to be unsuccessful. Having arrived at the correct answer, a good proportion then forgot that this question involves the use of g and neglected to write the final answer to either two or three significant figures thus losing the final mark. Other errors usually involved the omission of *m* from one or both terms, mixing the two masses and including an extra *g* in all of the terms.

Question 6

This question, involving a resultant force, was not well answered by many candidates, although there were also a fair number of full marks seen. There were two possible approaches (resolving and sine/cosine rule). Some treated it as an equilibrium problem and used correct terms in resolving but with sign errors. Some who used the triangle approach used a triangle with **R** (the resultant) opposite an angle of 150º rather than 30º. This enabled them to find the correct numerical value for the magnitude of **R** by the sine rule but then it was difficult to achieve any more marks since it was impossible to find a third angle. A number of candidates made no significant progress in answering this question; there was a lot of crossed out working seen.

Question 7

In part (a), most candidates were able to set up the two equations of motion, one for each of the two particles and most then went on to solve these correctly to find values for both *T* and *a*. A few persist in trying to use a "whole system" equation to find *a*, usually with limited success. In the second part the vast majority of candidates were unable to select the correct particle, forces or equation to score any of the marks. Part (c) also proved to be discriminating, with some weaker candidates not attempting it. Only a minority of candidates managed to produce a correct solution. Of those who did, many used the cosine rule applied to a vector triangle, or a resolution into two perpendicular components. Common misconceptions involved using just T + Tsin/cos alpha or answers involving components of 5g and 15g. Many had difficulty in identifying the correct size for the angle whichever method was attempted. A few very good candidates realised that the force acted along the angle bisector and scored five quick marks.

Question 8

Full marks were rarely achieved in this question. Some made a poor start by using *F=ma* in part (a) rather than an appropriate constant acceleration formula. In the second part many used separate equations of motion for the two particles (sometimes with extra or omitted terms) but then not uncommonly solved them as simultaneous equations with the same *F* (friction term), showing a lack of understanding of the problem. Only a minority used the more straightforward 'whole system' approach. There was some recovery in part (c) where follow through marks were available as long as the 'appropriate' terms were included in the equation of motion of one particle. A significant number of candidates knew that an inextensible string implied that the accelerations of the two particles were the same in part (d), but some of those went on to incorrectly mention the tension as well and so lost the mark. Many candidates who reached part (e) seemed to know they had to find the new deceleration but lost marks by including a tension or the 30N in their equation of motion.

Statistics for M1 Practice Paper Gold Level G5

				Mean score for students achieving grade:							
Qu	**Max score**	**Modal score**	**Mean %**	**ALL**	**A***	**A**	**B**	**C**	**D**	**E**	**U**
1	7		53	3.72		5.51	3.79	2.94	2.25	1.74	1.03
2	6		54	3.23		4.78	3.35	2.58	1.95	1.59	0.76
3	6		44	2.65		3.66	2.85	2.44	2.03	1.53	0.74
4	9		57	5.15	8.22	6.96	5.08	3.86	2.68	1.71	0.77
5	7	0	28	1.99	4.28	3.26	1.73	1.06	0.65	0.42	0.19
6	9		49	4.40		6.73	4.55	3.29	2.48	1.90	0.85
7	16		39	6.16		8.78	6.17	4.74	3.89	2.61	1.25
8	15		37	5.52		9.39	5.41	3.48	2.15	1.44	0.65
	75		**43.76**	**32.82**	**12.50**	**49.07**	**32.93**	**24.39**	**18.08**	**12.94**	**6.24**