

6677/01

Edexcel GCE

Mechanics M1

Gold Level G5

Time: 1 hour 30 minutes

Materials required for examination

Mathematical Formulae (Pink)

Items included with question papers

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

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M1), the paper reference (6677), your surname, other name and signature.

Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$.

When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.

Full marks may be obtained for answers to ALL questions.

There are 5 questions in this question paper, chosen from those which candidates have found the most difficult over the last 14 examination sessions. The total mark for this paper is 73.

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
51	44	37	30	22	13

1. A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

(a) the acceleration of the car and trailer, (3)

(b) the magnitude of the tension in the towbar. (3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

(c) find the value of F . (7)

2. **Figure 3**



Two particles A and B , of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough horizontal table. The string passes over a small smooth pulley P fixed on the edge of the table. The particle B hangs freely below the pulley, as shown in Figure 3. The coefficient of friction between A and the table is μ . The particles are released from rest with the string taut. Immediately after release, the magnitude of the acceleration of A and B is $\frac{4}{9}g$. By writing down separate equations of motion for A and B ,

(a) find the tension in the string immediately after the particles begin to move, (3)

(b) show that $\mu = \frac{2}{3}$. (5)

When B has fallen a distance h , it hits the ground and does not rebound. Particle A is then a distance $\frac{1}{3}h$ from P .

(c) Find the speed of A as it reaches P . (6)

(d) State how you have used the information that the string is light. (1)

3.

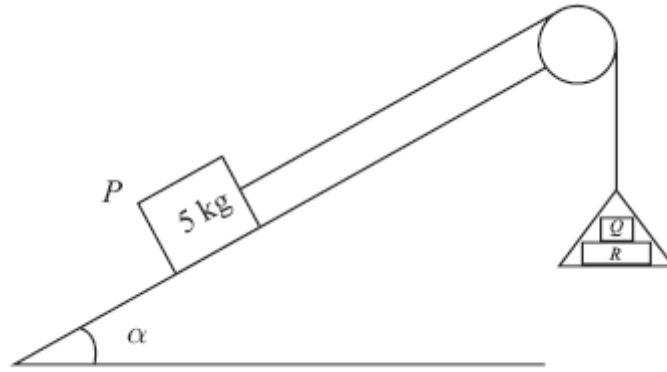


Figure 3

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 3. 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)**
-

4. 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)

5.



Figure 4

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 \mathbf{F} of magnitude 30 N is applied to Q in the direction PQ , as shown in Figure 4. 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 \mathbf{F} is removed.

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

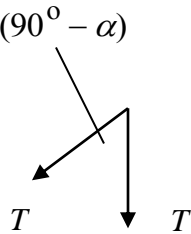
(4)

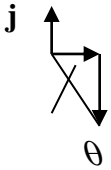
TOTAL FOR PAPER: 73 MARKS

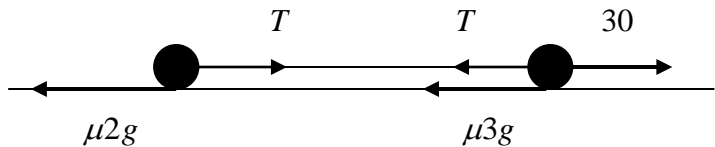
END

1.	(a)	For whole system: $1200 - 400 - 200 = 1000a$ $a = 0.6 \text{ m s}^{-2}$	M1 A1 A1 (3)
	(b)	For trailer: $T - 200 = 200 \times 0.6$ $T = 320 \text{ N}$	M1 A1 ft A1
	OR:	For car: $1200 - 400 - T = 800 \times 0.6$ $T = 320 \text{ N}$	OR: M1 A1 ft A1 (3)
(c)	For trailer: $200 + 100 = 200f$ or $-200f$ $f = 1.5 \text{ m s}^{-2}$ (-1.5) For car: $400 + F - 100 = 800f$ or $-800f$ $F = 900$ (N.B. For both: $400 + 200 + F = 1000f$)	M1 A1 A1 M1 A2 A1 (7)	
			(13 marks)

Question Number	Scheme	Marks
2(a)	$B: 2mg - T = 2m \times 4g/9$ $\Rightarrow T = \underline{10mg/9}$	M1 A1 A1 (3)
(b)	$A: T - \mu mg = m \times 4g/9$ Sub for T and solve: $\mu = 2/3$ *	M1 B1 A1 DM1 A1 (5)
(c)	When B hits: $v^2 = 2 \times 4g/9 \times h$ Deceleration of A after B hits: $ma = \mu mg \Rightarrow a = 2g/3$ Speed of A at P : $V^2 = 8gh/9 - 2 \times 2g/3 \times h/3$ $\Rightarrow V = \frac{2}{3} \sqrt{gh}$	M1 A1 M1 A1 ft. DM1 A1 (6)
(d)	Same tension on A and B	B1 (1)
		15

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

Question Number	Scheme	Marks
4	<p>(a)</p>  <p>$\tan \theta = \frac{2}{1} \Rightarrow \theta = 63.4^\circ$ angle is 153.4°</p> <p>(b)</p> <p>$(4 + p)\mathbf{i} + (q - 5)\mathbf{j}$ $(q - 5) = -2(4 + p)$ $2p + q + 3 = 0$ *</p> <p>(c)</p> <p>$q = 1 \Rightarrow p = -2$ $\Rightarrow \mathbf{R} = 2\mathbf{i} - 4\mathbf{j}$ $\Rightarrow \mathbf{R} = \sqrt{2^2 + (-4)^2} = \sqrt{20}$ $\sqrt{20} = m8\sqrt{5}$ $\Rightarrow m = \frac{1}{4}$</p>	<p>M1 A1 A1 (3)</p> <p>B1 M1 A1 A1 (4)</p> <p>B1 M1 M1 A1 f.t. M1 A1 f.t. A1 cao (7)</p> <p>[14]</p>

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

Examiner reports

Question 1

Part (a) was well done by the majority of candidates and a good number went on to use the answer correctly in part (b). If mistakes were made they were the usual sign errors or more seriously, in terms of marks lost, missing terms.

The third part was poorly done. There was confusion over the direction of the forces and the concept of thrust. A few candidates halved the thrust and used 50N in each equation. Some used the values of the acceleration and tension from previous parts.

Question 2

Most candidates attempted parts (a) and (b) using simultaneous equations, with the most common mistake being to cancel out either m or g when it was not a factor in every term. This resulted in the m term of T being missing. A relatively large number of candidates also lost the final A1 mark for part (b) as they worked through the question using decimals.

The first section of part (c) for calculating the velocity of A after B hits the ground was often calculated correctly although a common mistake was to use $h/3$. A large number of candidates took this to be the new velocity and finished the question at this point. Some continued to calculate the new acceleration but then struggled to form the final equation and a number used either g as the acceleration or $4g/9$.

Question 3

Most candidates attempted parts (a) and (b) using simultaneous equations, with the most common mistake being to cancel out either m or g when it was not a factor in every term. This resulted in the m term of T being missing. A relatively large number of candidates also lost the final A1 mark for part (b) as they worked through the question using decimals.

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Question 4

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 $(-5\mathbf{i} + 12\mathbf{j})$ into their working or from those candidates making errors with directions. Many candidates were able to visualise the situation well, realising that $7\mathbf{i}$ was involved, even though they may have made earlier errors in interpretation.

Question 5

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

Original paper	Qu	Mean score	Max score	Mean %	Mean score for students achieving grade:						
					ALL	A	B	C	D	E	U
0906	1	5.96	13	46	5.96	8.37	6.38	5.09	3.89	2.99	1.58
0801	2	6.16	15	41	6.16	10.68	6.66	4.13	3.16	1.68	1.09
0901	3	6.16	16	39	6.16	8.78	6.17	4.74	3.89	2.61	1.25
0901	4	5.51	14	39	5.51	9.08	4.46	3.05	2.20	1.57	0.64
0806	5	5.52	15	37	5.52	9.39	5.41	3.48	2.15	1.44	0.65
		29.31	73	40	29.31	46.30	29.08	20.49	15.29	10.29	5.21