Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Gold Level G2

Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	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 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
62	55	48	40	30	23

1. A particle P moves with constant acceleration $(2\mathbf{i} - 5\mathbf{j})$ m s^{-2}. At time $t = 0$, P has speed u m s^{-1}. At time $t = 3$ s, P has velocity $(-6\mathbf{i} + \mathbf{j})$ m s^{-1}.

Find the value of u.

(5)

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2. A small ball is projected vertically upwards from ground level with speed u m s^{-1}. The ball takes 4 s to return to ground level.

(*a*) Draw, in the space below, a velocity-time graph to represent the motion of the ball during the first 4 s.

(2)

(*b*) The maximum height of the ball above the ground during the first 4 s is 19.6 m. Find the value of u.

(3)

3.

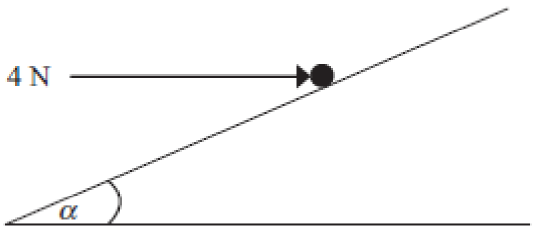

Figure 1

A particle of weight W newtons is held in equilibrium on a rough inclined plane by a horizontal force of magnitude 4 N. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$ as shown in Figure 1.

The coefficient of friction between the particle and the plane is $\frac{1}{2}$.

Given that the particle is on the point of sliding down the plane,

(i) show that the magnitude of the normal reaction between the particle and the plane is 20 N,

(ii) find the value of W.

(9)

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4. Three forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ acting on a particle P are given by

$$\mathbf{F}_1 = (7\mathbf{i} - 9\mathbf{j})\text{ N}$$
$$\mathbf{F}_2 = (5\mathbf{i} + 6\mathbf{j})\text{ N}$$
$$\mathbf{F}_3 = (p\mathbf{i} + q\mathbf{j})\text{ N}$$

where p and q are constants.

Given that P is in equilibrium,

(*a*) find the value of p and the value of q.

(3)

The force $\mathbf{F}_3$ is now removed. The resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ is $\mathbf{R}$. Find

(*b*) the magnitude of $\mathbf{R}$,

(2)

(*c*) the angle, to the nearest degree, that the direction of $\mathbf{R}$ makes with $\mathbf{j}$.

(3)

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5. At time $t = 0$, two balls A and B are projected vertically upwards. The ball A is projected vertically upwards with speed 2 m s^{-1} from a point 50 m above the horizontal ground. The ball B is projected vertically upwards from the ground with speed 20 m s^{-1}. At time $t = T$ seconds, the two balls are at the same vertical height, h metres, above the ground. The balls are modelled as particles moving freely under gravity.

Find

(*a*) the value of T,

(5)

(*b*) the value of h.

(2)

6.

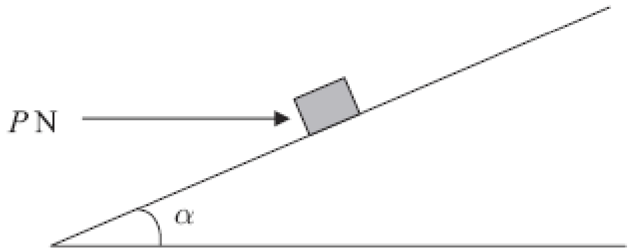

Figure 2

A small package of mass 1.1 kg is held in equilibrium on a rough plane by a horizontal force. The plane is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The force acts in a vertical plane containing a line of greatest slope of the plane and has magnitude P newtons, as shown in Figure 2.

The coefficient of friction between the package and the plane is 0.5 and the package is modelled as a particle. The package is in equilibrium and on the point of slipping down the plane.

(*a*) Draw, on Figure 2, all the forces acting on the package, showing their directions clearly.

(2)

(*b*) (i) Find the magnitude of the normal reaction between the package and the plane.

(ii) Find the value of P.

(11)

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7. 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)

8.

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 **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 **F** is removed.

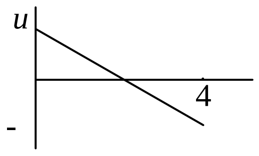
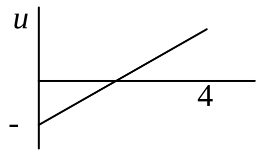
(*e*) Find the time between the instant that the force is removed and the instant that *Q* comes to rest.

(4)

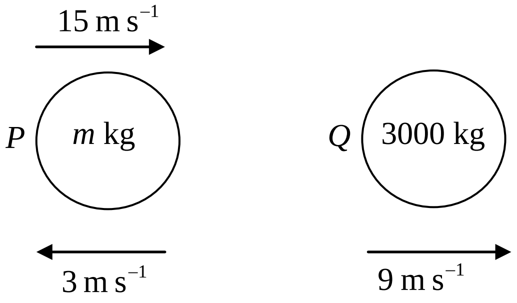
TOTAL FOR PAPER: 75 MARKS

END

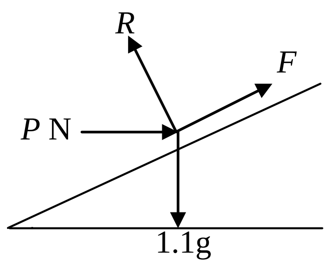
Question Number	Scheme	Marks
1	$-6\mathbf{i}+\mathbf{j}=\mathbf{u}+3(2\mathbf{i}-5\mathbf{j})$ $\Rightarrow \mathbf{u}=-12\mathbf{i}+16\mathbf{j}$ $\Rightarrow u=\sqrt{(-12)^2+16^2}=20$	M1 A1 A1 cso M1 A1 **[5]**

2 (a)	 <u>or</u>  shape values	 B1 B1 (2)
(b)	$19.6=\frac{1}{2}\times 2\times u$ $u=19.6$	M1 A1 A1 (3) **[5]**

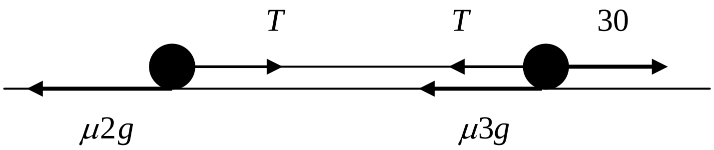
3.	↗ $4\cos\alpha+\mathrm{F}=\mathrm{W}\sin\alpha$ ↖ $\mathrm{R}=4\sin\alpha+\mathrm{W}\cos\alpha$ $\mathrm{F}=0.5\mathrm{R}$ $\cos\alpha=0.8$ or $\sin\alpha=0.6$ R = 20N ** GIVEN ANSWER W = 22N	M1 A1 M1 A1 B1 B1 M1 A1 A1 (9)
<u>**OR**</u>	→ $\mathrm{R}\sin\alpha=4+\mathrm{F}\cos\alpha$ ↑ $\mathrm{R}\cos\alpha+\mathrm{F}\sin\alpha=\mathrm{W}$ $\mathrm{F}=0.5\mathrm{R}$ $\cos\alpha=0.8$ or $\sin\alpha=0.6$ R = 20N ** GIVEN ANSWER W = 22N	M1 A1 M1 A1 B1 B1 M1 A1 A1 (9) **9**

Question Number	Scheme	Marks
4. (a)	$7 + 5 + p = 0$ or $-9 + 6 + q = 0$ $p = -12$ $q = 3$  	M1 A1 A1 (3)
(b)	$\mathbf{R} = 12\mathbf{i} - 3\mathbf{j}$ $\lvert\mathbf{R}\rvert = \sqrt{\left(12^2 + (-3)^2\right)} = \sqrt{153}$ or $3\sqrt{17}$ or 12.4 or better (N)	M1 A1 (2)
(c)	$\tan\theta = \frac{3}{12}$ $\theta = 14.03^0\ldots$ Angle with $\mathbf{j}$ is $104°$, to the nearest degree cao	M1 A1 A1 (3) **(8 marks)**

5. (a)	Use of $s = ut + \frac{1}{2}at^2$ $-2t + \frac{1}{2}gt^2$ (+ or – 50) $20t - \frac{1}{2}gt^2$ (+ or – 50) $50 = -2T + \frac{1}{2}gT^2 + 20T - \frac{1}{2}gT^2 = 18T$ $T = \frac{50}{18} = 2.777.... = 2.8$ or better	M1 A1 A1 M1 A1 **(5)**
(b)	$h = 20 \times T - 4.9 \times T^2 = 17.74.... \approx 17.7$ (18 to 2 s.f.) (use of 2.8 gives 17.584)	M1A1 **(2)** **[7]**

Question Number	Scheme	Marks
6(a)		B2 -1 e.e.o.o. (labels not needed) (2)
(b)	$F = \frac{1}{2}R$ $(\uparrow),\ R\cos\alpha + F\sin\alpha = mg$ $R = \dfrac{1.1g}{(\cos\alpha + \frac{1}{2}\sin\alpha)} = 9.8\text{ N}$ $(\rightarrow),\ P + \frac{1}{2}R\cos\alpha = R\sin\alpha$ $P = R(\sin\alpha - \frac{1}{2}\cos\alpha)$ $= 1.96$	B1 M1 A2 M1 A1 (6) M1 A2 M1 A1 (5) **[13]**

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

8.	(a)		
		$s = ut + \frac{1}{2}at^2 \quad \Rightarrow \quad 6 = \frac{1}{2}a \times 9$	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
$a = -\mu g$	
$v = u + at \Rightarrow 0 = 4 - \mu g t$	DM1
Leading to $t = \frac{6}{7}$ (s) accept 0.86, 0.857	A1 **(4)**
	[15]

Examiner reports

Question 1

Most candidates realised that they needed to apply $\mathbf{v} = \mathbf{u} + \mathbf{a}\, t$ and many arrived at $12\mathbf{i} - 16\mathbf{j}$ but then failed to go on and find the speed, losing the final two marks. This showed a lack of understanding of the relationship between speed and velocity. A small minority found magnitudes at the start and then tried to use $v = u + at$, gaining no marks. Some candidates lost the third mark because of errors in the manipulation of negative numbers.

Question 2

Only a relatively small number of candidates had a correct graph in part (a). There was a whole variety of incorrect attempts seen. Many of the graphs were curved and in some cases the path that the ball would take in the air was drawn. Of those who had a straight line many were reluctant to go below the t-axis into negative velocities and drew a speed-time graph instead. Part (b) was more successfully answered but a common error was to use a wrong time value. Students generally used constant acceleration formulae rather than the area under their graph.

Question 3

Although unstructured, this question provided a familiar scenario and was a good source of marks for many candidates. Most chose to resolve parallel and perpendicular to the plane despite the fact that horizontal and vertical resolutions lead to a much more straightforward solution. There were the usual problems of sign errors, with the friction often acting in the wrong direction, extra g's, a few sine/cosine mix ups and some poor algebra. Even those who had no idea how to solve their simultaneous equations could substitute $R = 20$ into one equation and find a value for W. A significant number of candidates resorted to finding the angle on their calculators or never mentioned sine/cosine = 0.6/0.8, thus losing the B mark and perhaps an accuracy mark. A few used $R = 20$ to find W then used W to find R!

Question 4

Although many candidates realised, in the first part, that equilibrium implied that both the sum of the **i** components and the sum of the j components was zero, some equated $p\mathbf{i} + q\mathbf{j}$ to the sum of the other two vectors, or, more rarely, to their difference. The exact numerical values of the constants were required to be stated explicitly, and statements such as '$p\mathbf{i} = -12$' or '$p = 12\mathbf{i}$' were penalised.

In part (b), the majority identified the correct resultant force, but did not always attempt to calculate the magnitude as required for the method mark. Most identified an appropriate 'arctan' in an attempt to find the angle in part (c), but a common mistake was to give the final answer as an angle with the **i** or **–j** directions, rather than 104° with the **j** direction. Most candidates achieved some marks for this question, but full marks were relatively rare.

Question 5

(a) Some candidates did not give clear explanations to justify why $AC = 4a\tan 60$, usually because they did not identify the right angle triangle formed by using the centre of the circle on the diagram given.

(b) Candidates needed to form and use three separate equations by resolving or taking moments. In the better solutions these equations were clearly labelled, but it was often necessary to guess what the candidate was trying to do. A clearly labelled diagram showing the labels and the directions of the forces acting helped to avoid errors. Some candidates formed sufficient equations but could not find a way to use their equations to find the value of μ. Although it is inconceivable that the rod might slip upwards and to the right, several candidates did have friction acting in the wrong direction, and friction did not always seem to be acting parallel to the direction of motion if the rod were to slip.

Question 6

Part (a) was usually correct with the majority of candidates producing a correct diagram. A significant minority had the friction force acting down the plane. In the second part by far the most popular approach was to resolve parallel and perpendicular to the plane, producing two simultaneous equations in *P* and *R*. There were many who went on to solve these correctly, but a common error was to find *R* in terms of *P*, use this to find a value for *P*, but then forget to go back and use it to find the value for *R*. A few of the more able students appreciated the idea of resolving perpendicular to an unknown force, and resolved vertically to find *R*, without the need to solve simultaneous equations.

Question 7

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 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 G2

Original paper	Qu	Mean score	Max score	Mean %	Mean score for students achieving grade: ALL	A	B	C	D	E	U
0901	**1**	3.13	5	63	3.13	3.71	3.13	2.68	2.58	2.46	1.68
0901	**2**	2.88	5	58	2.88	3.50	2.75	2.46	2.17	1.63	1.13
1106	**3**	6.25	9	69	6.25	8.29	7.14	5.93	4.60	3.28	1.55
1201	**4**	5.27	8	66	5.27	6.52	5.36	4.47	3.78	2.92	2.09
1306R	**5**	4.56	7	65	4.56	5.51	4.17	3.58	2.94	2.53	1.99
0901	**6**	7.93	13	61	7.93	10.50	8.22	6.40	5.33	3.52	1.90
0906	**7**	5.96	13	46	5.96	8.37	6.38	5.09	3.89	2.99	1.58
0806	**8**	5.52	15	37	5.52	9.39	5.41	3.48	2.15	1.44	0.65
		41.50	**75**	**55**	**41.50**	**55.79**	**42.56**	**34.09**	**27.44**	**20.77**	**12.57**