Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Gold Level G4

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
57	50	42	35	28	21

1. A particle P is moving with constant velocity $(-3\mathbf{i} + 2\mathbf{j})$ m s^{-1}. At time $t = 6$ s, P is at the point with position vector $(-4\mathbf{i} - 7\mathbf{j})$ m. Find the distance of P from the origin at time $t = 2$ s.

(5)

May 2010

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2. A woman travels in a lift. The mass of the woman is 50 kg and the mass of the lift is 950 kg. The lift is being raised vertically by a vertical cable which is attached to the top of the lift. The lift is moving upwards and has constant deceleration of 2 m s^{-2}. By modelling the cable as being light and inextensible, find

(*a*) the tension in the cable,

(3)

(*b*) the magnitude of the force exerted on the woman by the floor of the lift.

(3)

May 2013

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3. 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)

January 2012

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4. Two particles A and B are moving on a smooth horizontal plane. The mass of A is km, where $2 < k < 3$, 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 $4u$. As a result of the collision the speed of A is halved and its direction of motion is reversed.

(a) Find, in terms of k and u, the speed of B immediately after the collision.

(3)

(b) State whether the direction of motion of B changes as a result of the collision, explaining your answer.

(3)

Given that $k = \frac{7}{3}$,

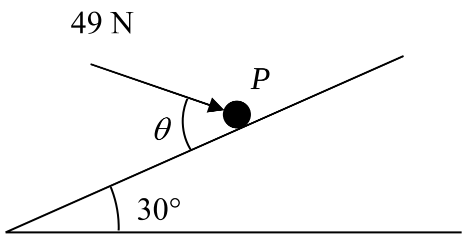
(c) find, in terms of m and u, the magnitude of the impulse that A exerts on B in the collision.

(3)

January 2009

5.

Figure 1



A particle P of mass 6 kg lies on the surface of a smooth plane. The plane is inclined at an angle of 30° to the horizontal. The particle is held in equilibrium by a force of magnitude 49 N, acting at an angle θ to the plane, as shown in Figure 1. The force acts in a vertical plane through a line of greatest slope of the plane.

(a) Show that $\cos \theta = \frac{3}{5}$.

(3)

(b) Find the normal reaction between P and the plane.

(4)

The direction of the force of magnitude 49 N is now changed. It is now applied horizontally to P so that P moves up the plane. The force again acts in a vertical plane through a line of greatest slope of the plane.

(c) Find the initial acceleration of P.

(4)

January 2008

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6. A car is travelling along a straight horizontal road. The car takes 120 s to travel between two sets of traffic lights which are 2145 m apart. The car starts from rest at the first set of traffic lights and moves with constant acceleration for 30 s until its speed is 22 m s^{-1}. The car maintains this speed for T seconds. The car then moves with constant deceleration, coming to rest at the second set of traffic lights.

(*a*) Sketch a speed-time graph for the motion of the car between the two sets of traffic lights.
(2)

(*b*) Find the value of T.
(3)

A motorcycle leaves the first set of traffic lights 10 s after the car has left the first set of traffic lights. The motorcycle moves from rest with constant acceleration, a m s^{-2}, and passes the car at the point A which is 990 m from the first set of traffic lights. When the motorcycle passes the car, the car is moving with speed 22 m s^{-1}.

(*c*) Find the time it takes for the motorcycle to move from the first set of traffic lights to the point A.
(4)

(*d*) Find the value of a.
(2)

May 2013

7. **Figure 2**

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 2. 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)

January 2008

8.

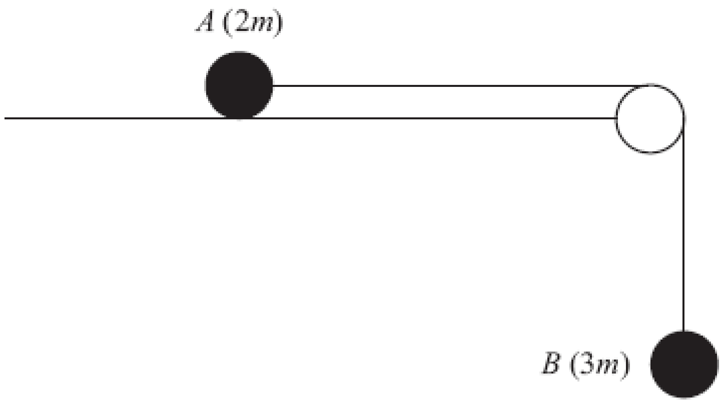


Figure 3

Two particles A and B have masses $2m$ and $3m$ respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a smooth horizontal table. The string passes over a small smooth pulley which is fixed at the edge of the table. Particle B hangs at rest vertically below the pulley with the string taut, as shown in Figure 3. Particle A is released from rest. Assuming that A has not reached the pulley, find

(*a*) the acceleration of B,

(5)

(*b*) the tension in the string,

(1)

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

(4)

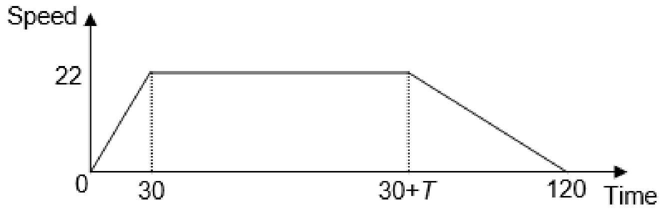
May 2013

TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1	$(-4\mathbf{i}-7\mathbf{j})=\mathbf{r}+4(-3\mathbf{i}+2\mathbf{j})$	M1 A1
	$\mathbf{r}=(8\mathbf{i}-15\mathbf{j})$	A1
	$\lvert\mathbf{r}\rvert=\sqrt{8^2+(-15)^2}=17$ m	M1 A1 ft
		[5]
2 (a)	For system, $(\uparrow)$, $T-950g-50g=1000\times -2$	M1 A1
	$T=7800$ N	A1
		(3)
(b)	For woman, $(\uparrow)$, $R-50g=50\times -2$	M1 A1
	$R=390$ N	A1
		(3)
		[6]
3 (a)	$7+5+p=0$ or $-9+6+q=0$	M1
	$p=-12$	A1
	$q=3$	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)	$\tan\theta=\frac{3}{12}$	M1
	$\theta=14.03^0...$	A1
	Angle with $\mathbf{j}$ is $104°$, to the nearest degree cao	A1
		(3)
		[8]

Question number	Scheme	Marks
4 (a)	$2u \rightarrow \quad \leftarrow 4u$ $\quad km2u - 4mu = -kmu + mv$ $km \quad m$ $\quad u(3k-4) = v$ $u \leftarrow \quad \rightarrow v$	M1 A1 A1 **(3)**
(b)	$k > 2 \Rightarrow v > 0 \Rightarrow$ dir^n of motion reversed	M1A1A1 cso **(3)**
(c)	For B, $\quad m(u(3k-4) - -4u)$ $= 7mu$	M1 A1 f.t. A1 **(3)** **[9]**
5 (a)	R (// plane): $\quad 49 \cos \theta = 6g \sin 30$ $\Rightarrow \cos \theta = 3/5$ *	M1 A1 A1 **(3)**
(b)	R (perp to plane): $\quad R = 6g \cos 30 + 49 \sin \theta$ $R \approx$ <u>90.1 or 90 N</u>	M1 A1 DM1 A1 **(4)**
(c)	R (// to plane): $\quad 49 \cos 30 - 6g \sin 30 = 6a$ $\Rightarrow a \approx 2.17$ or 2.2 m s^{-2}	M1 A2,1,0 A1 **(4)** **[11]**

Question number	Scheme	Marks
6 (a)	 Shape Figures	B1 B1 **(2)**
(b)	$\frac{(120+T)22}{2} = 2145$ $T = 75$	M1 A1 A1 **(3)**
(c)	$\frac{(t+t-30)22}{2} = 990$ $t = 60$ $Answer = 60 - 10 = 50$	M1 A1 A1 A1 **(4)**
(d)	$990 = 0.5a50^2$ $a = 0.79,\ 0.792,\ 99/125$ oe	M1 A1 **(2)** **[11]**

Question number	Scheme	Marks
7 (a)	B: $2mg - T = 2m \times 4g/9$	M1 A1
	$\Rightarrow T = \underline{10mg/9}$	A1
		(3)
(b)	A: $T - \mu \underline{mg} = m \times 4g/9$	M1 B1 A1
	Sub for T and solve: $\mu = 2/3$ *	DM1 A1
		(5)
(c)	When B hits: $v^2 = 2 \times 4g/9 \times h$	M1 A1
	Deceleration of A after B hits: $ma = \mu mg \Rightarrow a = 2g/3$	M1 A1 ft
	Speed of A at P: $V^2 = 8gh/9 - 2 \times 2g/3 \times h/3$	DM1
	$\Rightarrow V = \frac{2}{3}\sqrt{(gh)}$	A1
		(6)
(d)	Same tension on A and B	B1
		(1)
		[15]
8 (a)	For A, $T = 2ma$	B1
	For B, $3mg - T = 3ma$	M1 A1
	$3mg = 5ma$	**DM**1
	$\frac{3g}{5} = a$ (5.9 or 5.88 m s^{-2})	A1
		(5)
(b)	$T = 6mg/5$; $12m$; $11.8m$	B1
		(1)
(c)	$F = \sqrt{T^2 + T^2}$	M1 A1 **ft**
	$F = \frac{6mg\sqrt{2}}{5}$;$1.7mg$ (or better);$16.6m$;$17m$	A1
	Direction clearly marked on a diagram, with an arrow, and 45° (oe) marked	B1
		(4)
		[10]

Examiner reports

Question 1

This proved to be a tricky opening question for many of the candidates. The most popular approach was to find the starting position and then use it to find the position vector at $t = 2$. Errors in sign were fairly common at some stage of the working. A significant minority did not use a valid method at all, some just multiplying the given velocity vector by 2 or using a time of 6 only, and others becoming confused with constant acceleration formulae. A number of candidates failed to find the magnitude of their position vector to obtain the distance as required; there were follow through marks available for this even if the vector had been determined incorrectly. A few found the distance from the starting point rather than from the origin. Nevertheless, there were a fair number of entirely correct solutions.

Question 2

Part (a) was mostly well done with the vast majority attempting an equation of motion for the whole system. The most common error was the omission of the minus sign on the acceleration. The second part proved to be a discriminator and revealed a lack of understanding of the basic principles. A significant number treated it as a statics problem, even though they had used an acceleration in part (a), and tried assuming the forces were in equilibrium. Amongst those who did attempt to write down an equation of motion for the woman alone, there was much confusion over which forces were acting on her, with many including the tension in the lift cable.

Question 3

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 4

Almost all candidates attempted to use a conservation of momentum equation in part (a) but there were many who either did not draw a diagram at all or else drew one which did not show the directions of motion of each particle after the collision. This lead to problems in all three parts of the question. Few realised the significance of the question asking for the *speed* of B, and gave a negative answer $u(4 - 3k)$. There were also sign errors in the momentum equation and general problems dealing with the algebra. The second part required the significance of the range of values of k to be explicitly referred to in the identification of direction and there were a number of fully correct and often well-expressed solutions. However, many did not mention k at all and scored little. In part (c), many knew the relevant impulse-momentum equation and attempted to apply it to one of the particles but there was often confusion over direction and substitution of values and some gave a negative answer, losing the final mark.

Question 5
Throughout this question candidates' answers were marred by confusion between 30°/ θ, cos/sin, and even horizontal/ parallel to the plane.

Part (a) caused a few problems and sometimes it was not attempted, even though parts (b) and (c) were fully correct. An exact fraction, using g = 9.8, was required so that recourse to inexact decimals lost marks. In part (b) a significant number of candidates lost the final mark by leaving their answer as 90.12. In the final part many candidates treated the 49 as a force up the slope, rather than horizontal, so failed to resolve up the slope thus failing to score any marks here.

Question 6
In part (a) very few candidates failed to score the first B1, but the second was lost in one of two ways either by omitting a figure (usually the 120), or by labelling the $T + 30$ term as T. In the second part almost all candidates tried equating the area under the graph to 2145; those who used the whole trapezium were almost invariably successful, but the candidates who split it into two triangles and a rectangle often made errors such as writing the last time interval as $(120 - T)$ or simplifying $(120 - (30 + T))$ to obtain $(90 + T)$. Candidates were able to score full marks in parts (c) and (d) even if part (b) was wrong. The most common error in part (c) was assuming that when the motorcycle passed the car they had not only covered equal distances of 990 m but were also both travelling at 22 m s^{-1}. Many subtracted the distance travelled in the first part of the motion, 330 m, from 990 m and divided by 22 to obtain the 30 s part of the car's time, but failed to carry out one or both of the remaining steps (adding the other 30 s and subtracting 10 s). In the final part many scored a method mark for using a wrong time from part (c) correctly, but many scored no marks by persisting with $v = 22$ for the motorcycle.

Question 7
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.

Very few candidates gained the final B1 mark, with most stating that the weight of the string did not need to be taken into consideration. The mark was not given for a correct reason if other incorrect anwers were also included.

Question 8

In part (a) the vast majority of candidates attempted to write down separate equations of motion for the two particles. Occasionally 'g' was omitted from the weight term or, more rarely, included in the 'ma' term and sometimes the masses were given as 2 and 3 rather than $2m$ and $3m$. A more significant error was including a weight term for the particle that is moving horizontally. Almost all solved their equations and found a value for the acceleration and full marks for this part were often achieved. In the second part, the mark for the value of the tension required a correct answer to appropriate accuracy, 2 or 3 significant figures if g = 9.8 is used, but the exact answer $\frac{6mg}{5}$ was also acceptable. A fairly common error, apart from over-accuracy, was to omit m, despite it having been included in the original equations. Part (c) presented greater difficulties for many candidates and it was sometimes omitted. The resultant of the tension forces acting on the pulley was required. Some candidates had different vertical and horizontal forces such as $T + 3mg$, $3mg$ and/or $2mg$, and some thought that the resultant must act vertically downwards. Those who realised that they had to combine the two perpendicular tensions generally used a valid method, Pythagoras or resolving at a 45° angle, to find the magnitude of the resultant but omission of m was again a common error. Over-accuracy is only penalised once per question and, as before, an exact answer in terms of g was credited. Some candidates failed to gain the final independent mark for the direction by not showing it clearly on a diagram; 'at 45° to the horizontal' was not sufficient on its own and SW is not appropriate here.

Statistics for M1 Practice Paper Gold Level G4

Qu	Max score	Modal score	Mean %	Mean score for students achieving grade: ALL	A*	A	B	C	D	E	U
1	5		56	2.81	4.51	4.03	3.07	2.31	1.76	1.31	0.68
2	6	6	56	3.38	5.18	4.60	3.71	3.11	2.56	1.97	1.05
3	8		66	5.27	7.34	6.52	5.36	4.47	3.78	2.92	2.09
4	9		54	4.88		6.50	4.95	3.81	3.20	2.27	1.04
5	11		57	6.26		8.71	6.65	5.04	3.58	2.00	0.88
6	11	5	55	6.07	9.15	8.08	6.42	5.59	4.81	4.10	2.68
7	15		41	6.16		10.68	6.66	4.13	3.16	1.68	1.09
8	10	5	45	4.51	7.80	6.70	5.05	3.95	2.88	1.87	0.69
	75		**52.45**	**39.34**	**33.98**	**55.82**	**41.87**	**32.41**	**25.73**	**18.12**	**10.20**