Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1
Silver Level S5

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

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
67	59	50	42	32	25

1. Two particles A and B, of mass 2 kg and 3 kg respectively, are moving towards each other in opposite directions along the same straight line on a smooth horizontal surface. The particles collide directly. Immediately before the collision the speed of A is 5 m s^{-1} and the speed of B is 6 m s^{-1}. The magnitude of the impulse exerted on B by A is 14 N s.

Find

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

(3)

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

(3)

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2. A ball is thrown vertically upwards with speed u m s^{-1} from a point P at height h metres above the ground. The ball hits the ground 0.75 s later. The speed of the ball immediately before it hits the ground is 6.45 m s^{-1} . The ball is modelled as a particle.

(a) Show that $u = 0.9$.

(3)

(b) Find the height above P to which the ball rises before it starts to fall towards the ground again.

(2)

(c) Find the value of h.

(3)

3.

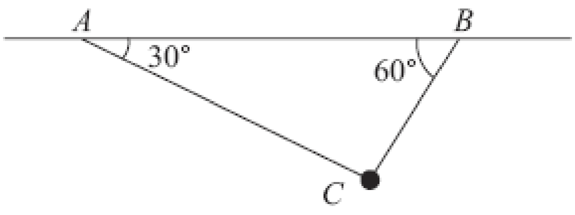

Figure 1

A particle of mass m kg is attached at C to two light inextensible strings AC and BC. The other ends of the strings are attached to fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with AC and BC inclined to the horizontal at 30° and 60° respectively, as shown in Figure 1.

Given that the tension in AC is 20 N, find

(a) the tension in BC,

(4)

(b) the value of m.

(4)

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4. A beam AB has length 6 m and weight 200 N. The beam rests in a horizontal position on two supports at the points C and D, where AC = 1 m and DB = 1 m. Two children, Sophie and Tom, each of weight 500 N, stand on the beam with Sophie standing twice as far from the end B as Tom. The beam remains horizontal and in equilibrium and the magnitude of the reaction at D is three times the magnitude of the reaction at C. By modelling the beam as a uniform rod and the two children as particles, find how far Tom is standing from the end B.

(7)

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5. A particle P is projected vertically upwards from a point A with speed u m s^{-1}. The point A is 17.5 m above horizontal ground. The particle P moves freely under gravity until it reaches the ground with speed 28 m s^{-1}.

(*a*) Show that $u = 21$.

(3)

At time t seconds after projection, P is 19 m above A.

(*b*) Find the possible values of t.

(5)

The ground is soft and, after P reaches the ground, P sinks vertically downwards into the ground before coming to rest. The mass of P is 4 kg and the ground is assumed to exert a constant resistive force of magnitude 5000 N on P.

(*c*) Find the vertical distance that P sinks into the ground before coming to rest.

(4)

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6. [*In this question, the unit vectors* **i** *and* **j** *are due east and due north respectively.*]

A particle P is moving with constant velocity $(-5\mathbf{i} + 8\mathbf{j})$ m s^{-1}. Find

(*a*) the speed of P,

(2)

(*b*) the direction of motion of P, giving your answer as a bearing.

(3)

At time $t = 0$, P is at the point A with position vector $(7\mathbf{i} - 10\mathbf{j})$ m relative to a fixed origin O. When $t = 3$ s, the velocity of P changes and it moves with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}, where u and v are constants. After a further 4 s, it passes through O and continues to move with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}.

(*c*) Find the values of u and v.

(5)

(*d*) Find the total time taken for P to move from A to a position which is due south of A.

(3)

7.

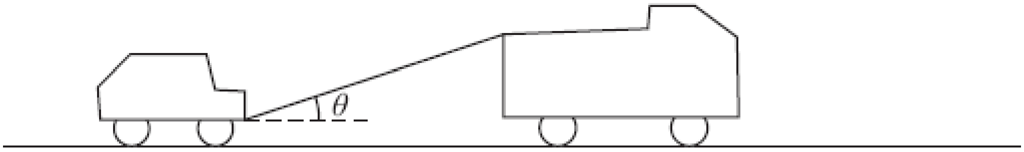


Figure 4

A truck of mass 1750 kg is towing a car of mass 750 kg along a straight horizontal road. The two vehicles are joined by a light towbar which is inclined at an angle θ to the road, as shown in Figure 4. The vehicles are travelling at 20 m s^{-1} as they enter a zone where the speed limit is 14 m s^{-1}. The truck's brakes are applied to give a constant braking force on the truck. The distance travelled between the instant when the brakes are applied and the instant when the speed of each vehicle is 14 m s^{-1} is 100 m.

(*a*) Find the deceleration of the truck and the car.

(3)

The constant braking force on the truck has magnitude *R* newtons. The truck and the car also experience constant resistances to motion of 500 N and 300 N respectively.

Given that cos θ = 0.9, find

(*b*) the force in the towbar,

(4)

(*c*) the value of *R*.

(4)

8.

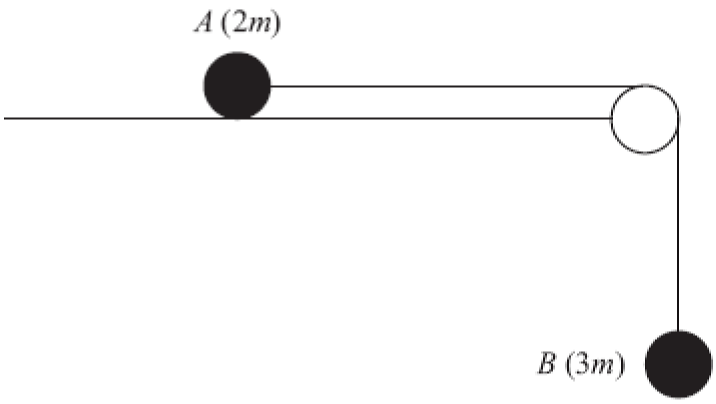


Figure 2

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 2. 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.

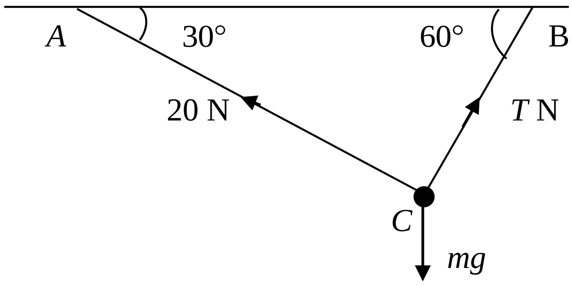
(4)

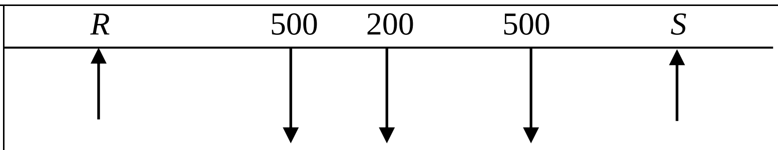
TOTAL FOR PAPER: 75 MARKS

END

Question Number	Scheme	Marks
1(a)		
	$2v + 10 = 14$	M1A1
	$v = 2 \text{ m s}^{-1}$	A1
		(3)
(b)	$3w + 18 = 14$	M1A1
	$w = \frac{4}{3} \text{ m s}^{-1}$	A1
		(3)
		[6]

Question Number	Scheme	Marks
2. **(a)**	$-6.45 = u - 9.8 \times 0.75$	M1 A1
	$0.9 = u$ **	A1
		(3)
(b)	$0 = 0.81 - 2 \times 9.8 \times s$	M1
	$s = 0.041$ or 0.0413	A1
		(2)
(c)	$h = -0.9 \times 0.75 + 4.9 \times 0.75^2$	M1 A1
	$h = 2.1$ or 2.08	A1
		(3)
		[8]

Question Number	Scheme	Marks
Q3.		
	(a) R($\rightarrow$) $20\cos 30° = T\cos 60°$	M1 A2 (1,0)
	$T = 20\sqrt{3}$, 34.6, 34.64,…	A1 (4)
	(b) R($\uparrow$) $mg = 20\sin 30° + T\sin 60°$	M1 A2 (1,0)
	$m = \frac{40}{g} (\approx 4.1)$,4.08	A1 (4)
		[8]

Q4		
	$M(B)$,	
	$500x + 500.2x + 200\text{x}3 = R\text{x}5 + S\text{x}1$ (or any valid moments equation)	M1 A1 A1
	($\downarrow$) $R + S = 500 + 500 + 200 = 1200$ (or a moments equation)	M1 A1
	solving for x; $x = 1.2$ m	M1 A1 cso
		[7]

Question Number	Scheme		Marks	
5.	(a) $v^2 = u^2 + 2as \Rightarrow 28^2 = u^2 + 2\times 9.8\times 17.5$		M1 A1	
	Leading to $u = 21$ ✱	cso	A1	(3)
	(b) $s = ut + \frac{1}{2}at^2 \Rightarrow 19 = 21t - 4.9t^2$		M1 A1	
	$4.9t^2 - 21t + 19 = 0$			
	$t = \frac{21 \pm \sqrt{21^2 - 4\text{x}4.9\text{x}19}}{9.8}$			
	t = 2.99 or 3.0		DM1 A1 A1	
	t = 1.30 or 1.3			(5)
	(c) N2L $4g - 5000 = 4a$		M1 A1	
	$(a = -1240.2)$			
	$v^2 = u^2 + 2as \Rightarrow 0^2 = 28^2 - 2\times 1240.2\times s$			
	Leading to $s = 0.316$ (m)	or 0.32	M1 A1	(4)
				[12]

6.(a)	Speed = $\sqrt{(5^2 + 8^2)} \approx$ 9.43 m s^{-1}	M1 A1 (2)
(b)	Forming arctan 8/5 or arctan 5/8 oe	M1
	Bearing = 360 – arctan 5/8 or 270 + arctan 8/5 = 328	DM1 A1 (3)
(c)	At $t = 3$, p.v. of P = $(7 - 15)\mathbf{i} + (-10 + 24)\mathbf{j} = -8\mathbf{i} + 14\mathbf{j}$	M1 A1
	Hence $-8\mathbf{i} + 14\mathbf{j} + 4(u\mathbf{i} + v\mathbf{j}) = \mathbf{0}$	M1
	$\Rightarrow u = 2,\ v = -3.5$	DM1 A1 (5)
(d)	p.v. of P t secs after changing course = $(-8\mathbf{i} + 14\mathbf{j}) + t(2\mathbf{i} - 3.5\mathbf{j})$	M1
	= $7\mathbf{i}$ + …..	DM1
	Hence total time = 10.5 s	A1 (3)
		13

Question Number	Scheme	Marks
7 **(a)**	Use of $v^2 = u^2 + 2as$ $14^2 = 20^2 - 2a \times 100$ Deceleration is 1.02(m s^{-2})	M1 A1 A1 **(3)**
(b)	Horizontal forces on the car: $\pm T\cos\theta - 300 = 750 \times -1.02 = -765$ $T = -1550/3$ The force in the tow-bar is 1550/3, 520 (N) or better (allow –ve answer)	M1A2 **f.t.** A1 **(4)**
(c)	Horizontal forces on the truck: $\pm T\cos\theta - 500 - R = 1750 \times -1.02$ Braking force $R =$ 1750 (N)	M1A2 **f.t.** A1 **(4)** **[11]**

8. **(a)**	For *A*, $T = 2ma$ For *B*, $3mg - T = 3ma$ $3mg = 5ma$ $\frac{3g}{5} = a$ (5.9 or 5.88 m s^{-2})	B1 M1 A1 **DM**1 A1 **(5)**
(b)	$T = 6mg/5$; $12m$; $11.8m$	B1 **(1)**
(c)	$F = \sqrt{T^2 + T^2}$ $F = \frac{6mg\sqrt{2}}{5}$; $1.7mg$ (or better); $16.6m$; $17m$ Direction clearly marked on a diagram, with an arrow, and 45^o (oe) marked	M1 A1 **ft** A1 B1 **(4)** **[10]**

Examiner reports

Question 1

This question was generally well answered. In part (a), almost all candidates quoted and used an appropriate formula for impulse in terms of difference of momenta to gain the method mark but many made a sign error in their equation and some who had a correct equation but with a negative v forgot to then state $v = 2$ and so lost the final mark as speed was required. In the second part, most also gained the method mark either for an impulse-momentum equation or conservation of momentum equation but again similar errors were made. It was not uncommon to see these marks earned first and then conservation of momentum used to find the speed of A.

Question 2

In part (a) relatively few were able to show that $u = 0.9$ exactly. It must be stressed that when an answer is given, the method used must be clear and fully correct. Many candidates fudged the signs in their methods, failing to appreciate that u was a speed and therefore positive, or else used an inexact method. The second part elicited many correct responses for finding the height reached above the point of projection. However, the answer was not always given to the required 2 or 3 significant figures, consistent with the use of g = 9.8 and answers to one or four significant figures were penalised. There were many possible approaches for finding the required height in part (c); sign errors were fairly common and some found the total height reached by the ball. Others found the correct value but added or subtracted another distance to produce their final answer showing a lack of real understanding of the situation. Nevertheless, there were some entirely correct systematic solutions seen.

Question 3

Far too many candidates worked with the triangle as given in the diagram, rather than with a (vector) triangle of forces. Use of incorrect trig. ratios was the main source of error for those who chose to resolve horizontally and vertically. Relatively few chose to exploit the fact that the tensions were at right angles by resolving along the strings. Some did successfully work with a (right-angled) triangle of forces and a tiny minority used the ‘old-fashioned’ Lami’s Theorem. In part (a), since g was not involved, the answer needed to be given to at least 2 sf but otherwise there was no limit to the number of figures accepted. However, in the second part, since the answer was dependent on g, decimal answers needed to be given to either 2 or 3 sf and more accurate versions were penalised.

Question 4

This question was well answered, particularly by those who resolved vertically to produce one of their equations. Those who took moments about two different points had a higher failure rate, partly because of the need to represent more lengths in terms of x and partly because of the heavier algebra required. Most had the R and $3R$ the right way round, and few were tempted to swap over Tom and Sophie. There were seven significant points on the beam, and the candidates between them took moments about all seven. The least successful seemed to be those who took moments about Tom’s position, which generally led to errors in the distances. A few took moments about a point but equated the sum of the moments to the reaction at the point producing a dimensionally incorrect equation and losing all the marks for that equation. It was rare to see g’s being used.

Question 5

Part (a) was generally well done with most candidates using the figures 28, 9.8 and 17.5 in a constant acceleration formula to obtain the given '$u = 21$'. Occasionally there was a sign error, and although the correct answer was quoted, it did not actually follow from the working. Some considered the motion 'up' and 'down' separately, and used the distances to successfully derive the value of 'u'.

The most common approach in part (b) was to write down a quadratic equation in t, and to solve it using the quadratic formula. Sometimes an inappropriate distance was used such as 1.5 or 36.5 (rather than 19) which showed a lack of understanding of the mechanics of the situation and so achieved no credit. There were occasional sign errors in the equation, and some were either unable to deal with the quadratic at all or misquoted the formula. Nevertheless, a significant number did successfully find the two values of t (accuracy to 2 or 3 significant figures was required following the use of $g = 9.8$). The alternative approach of 'up' and 'down' separately was seen, but often only one of the times was calculated correctly.

Part (c) proved more of a challenge for many; some omitted it and, although many recognised that it was necessary to calculate a deceleration as the particle moved through the ground, a very common mistake was to consider the resistance only and neglect the weight term. Those candidates could go on to achieve one of the four possible marks by substituting their deceleration into an appropriate constant acceleration formula. Again, accuracy to 2 or 3 significant figures was expected (over-accuracy or use of $g = 9.81$ is penalised by a maximum of one mark per question). A 'work-energy' approach was an alternative valid method but candidates often only considered the change in kinetic energy and not potential energy.

Question 6

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 7

This question provided some much needed discrimination. Part (a) was usually fine but some lost the final mark for giving a negative answer. In the second and third parts candidates were at least partially successful but it was very common to see sign errors in the equations of motion. Some who found T correctly in part (b) then forgot to resolve it in part (c). Another common error was to include R in the forces acting on the car and not on the truck.

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 Silver Level S5

					Mean score for students achieving grade:						
Original paper	**Qu**	**Mean score**	**Max score**	**Mean %**	**ALL**	**A**	**B**	**C**	**D**	**E**	**U**
1306R	**1**	4.37	6	73	4.37	4.90	4.25	3.73	3.39	3.42	2.53
1101	**2**	5.03	8	63	5.03	6.02	4.87	3.89	3.09	2.63	1.58
1001	**3**	5.67	8	71	5.67	7.19	5.90	4.78	3.61	2.58	1.42
1006	**4**	4.95	7	71	4.95	6.37	5.66	4.97	3.93	2.68	1.18
1206	**5**	7.65	12	64	7.65	10.03	8.44	7.05	5.75	4.53	2.67
0801	**6**	7.39	13	57	7.39	9.48	6.59	4.95	4.03	3.18	2.26
1306R	**7**	6.09	11	55	6.09	7.62	5.69	4.71	3.59	3.64	2.30
1306	**8**	4.51	10	45	4.51	6.70	5.05	3.95	2.88	1.87	0.69
		45.66	**75**	**61**	**45.66**	**58.31**	**46.45**	**38.03**	**30.27**	**24.53**	**14.63**