Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Silver Level S3

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
68	60	52	44	36	28

1. Two particles A and B, of mass $5m$ kg and $2m$ kg respectively, are moving in opposite directions along the same straight horizontal line. The particles collide directly. Immediately before the collision, the speeds of A and B are 3 m s^{-1} and 4 m s^{-1} respectively. The direction of motion of A is unchanged by the collision. Immediately after the collision, the speed of A is 0.8 m s^{-1}.

(a) Find the speed of B immediately after the collision.

(3)

In the collision, the magnitude of the impulse exerted on A by B is 3.3 N s.

(b) Find the value of m.

(3)

May 2012

2.

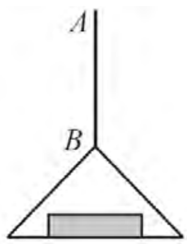

Figure 1

A vertical rope AB has its end B attached to the top of a scale pan. The scale pan has mass 0.5 kg and carries a brick of mass 1.5 kg, as shown in Figure 1. The scale pan is raised vertically upwards with constant acceleration 0.5 m s^{-2} using the rope AB. The rope is modelled as a light inextensible string.

(a) Find the tension in the rope AB.

(3)

(b) Find the magnitude of the force exerted on the scale pan by the brick.

(3)

June 2016

3.

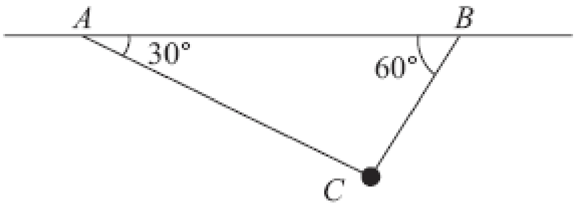

Figure 2

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 2.

Given that the tension in AC is 20 N, find

(*a*) the tension in BC,

(4)

(*b*) the value of m.

(4)

January 2010

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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)

May 2010

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5. Two cars P and Q are moving in the same direction along the same straight horizontal road. Car P is moving with constant speed 25 m s^{-1}. At time t = 0, P overtakes Q which is moving with constant speed 20 m s^{-1}. From t = T seconds, P decelerates uniformly, coming to rest at a point X which is 800 m from the point where P overtook Q. From t = 25 s, Q decelerates uniformly, coming to rest at the same point X at the same instant as P.

(*a*) Sketch, on the same axes, the speed-time graphs of the two cars for the period from t = 0 to the time when they both come to rest at the point X.

(4)

(*b*) Find the value of T.

(8)

May 2010

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6. 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)

May 2012

7.

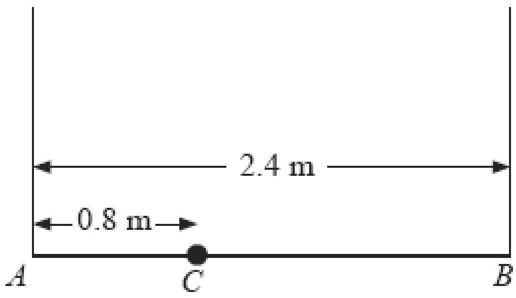

Figure 3

A plank AB has mass 12 kg and length 2.4 m. A load of mass 8 kg is attached to the plank at the point C, where $AC = 0.8$ m. The loaded plank is held in equilibrium, with AB horizontal, by two vertical ropes, one attached at A and the other attached at B, as shown in Figure 3. The plank is modelled as a uniform rod, the load as a particle and the ropes as light inextensible strings.

(*a*) Find the tension in the rope attached at B.

(4)

The plank is now modelled as a non-uniform rod. With the new model, the tension in the rope attached at A is 10 N greater than the tension in the rope attached at B.

(*b*) Find the distance of the centre of mass of the plank from A.

(6)

May 2008

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8. [*In this question,* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given with respect to a fixed origin*.]

A ship S is moving along a straight line with constant velocity. At time t hours the position vector of S is $\mathbf{s}$ km. When $t = 0$, $\mathbf{s} = 9\mathbf{i} - 6\mathbf{j}$. When $t = 4$, $\mathbf{s} = 21\mathbf{i} + 10\mathbf{j}$. Find

(*a*) the speed of S,

(4)

(*b*) the direction in which S is moving, giving your answer as a bearing.

(2)

(*c*) Show that $\mathbf{s} = (3t + 9)\,\mathbf{i} + (4t - 6)\,\mathbf{j}$.

(2)

A lighthouse L is located at the point with position vector $(18\mathbf{i} + 6\mathbf{j})$ km. When $t = T$, the ship S is 10 km from L.

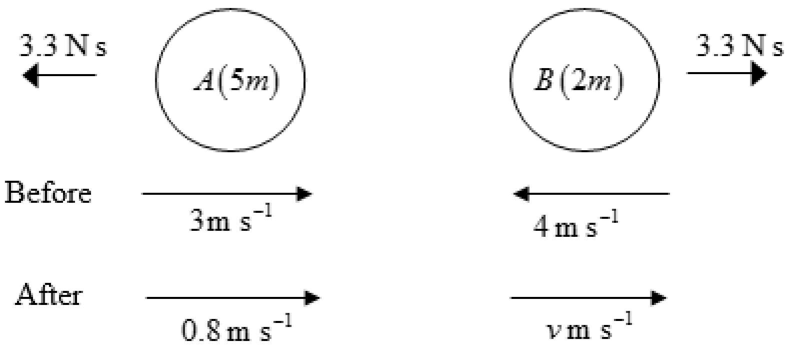
(*d*) Find the possible values of T.

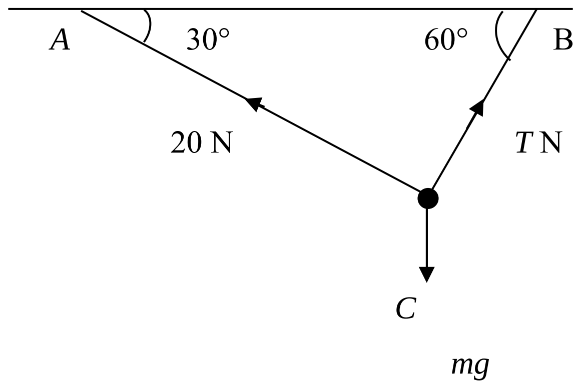
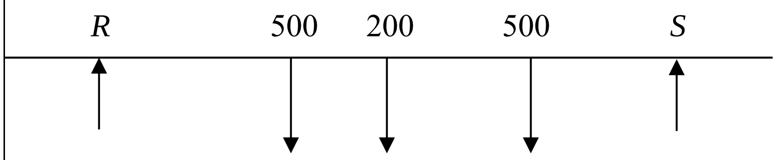
(6)

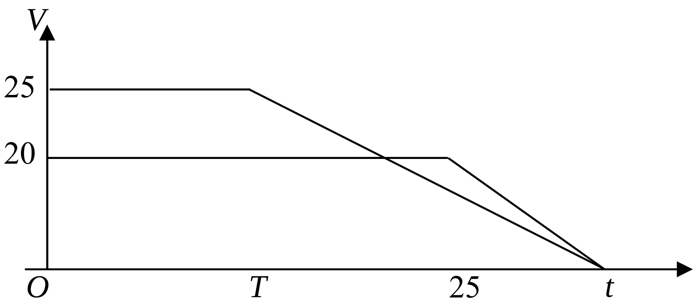
January 2010

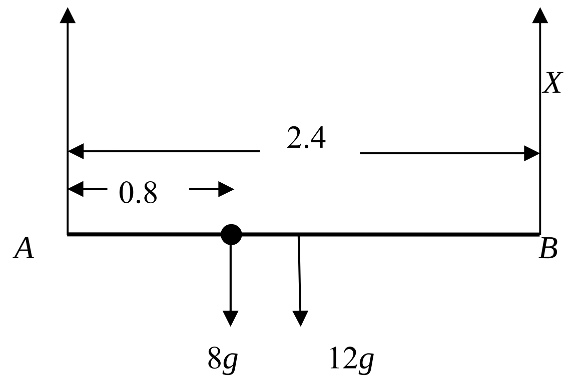
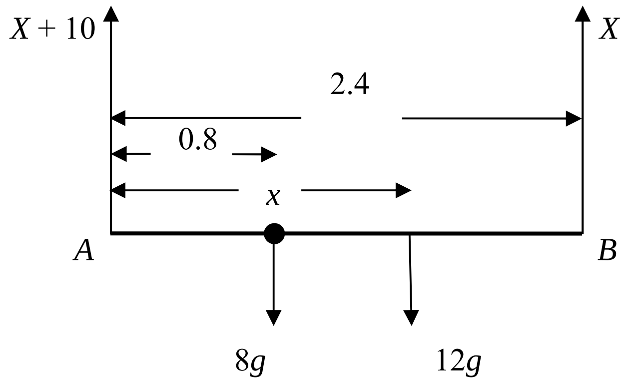
TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)		
	CLM $5m\times3-2m\times4=5m\times0.8+2mv$	M1 A1
	Leading to $v=1.5$ (Speed is 1.5 m s^{-1})	A1
		(3)
(b)	Impulse for A $5m(0.8-3)=-3.3$	M1 A1
	Leading to $m=0.3$	A1
		(3)
		[6]
2 (a)	$T-0.5g-1.5g=2\times0.5$	M1 A1
	$T=20.6$ (N) or 21 (N)	A1
		(3)
(b)	$R-1.5g=1.5\times0.5$	M1 A1
	Force = 15.5 (N) or 15 (N)	A1
		(3)
		OR
	OR: $T-R-0.5g=0.5\times0.5$	M1 A1
	Force = 15.5 (N) or 15 (N)	A1
		(3)
		[6]

Question number	Scheme	Marks
3 (a)		
	R(→) $20\cos 30° = T\cos 60°$	M1 A2 (1,0)
	$T = 20\sqrt{3}$, 34.6, 34.64,…	A1
		(4)
(b)	R(↑) $mg = 20\sin 30° + T\sin 60°$	M1 A2 (1,0)
	$m = \frac{40}{g} (\approx 4.1)$,4.08	A1
		(4)
		[8]
4		
	$M(B)$, $500x + 500.2x + 200\text{x}3 = R\text{x}5 + S\text{x}1$ (or any valid moments equation)	M1 A1 A1
	(↓) $R + S = 500 + 500 + 200 = 1200$ (or a moments equation)	M1 A1
	solving for x; $x = 1.2$ m	M1 A1 cso
		[7]

Question number	Scheme	Marks
5 (a)	 Shape (both) Cross Meet on t-axis Figures 25,20,T,25	B1 B1 B1 B1 **(4)**
(b)	For Q: $20\left(\frac{t+25}{2}\right)=800$	M1 A1
	$t=55$	**DM1** A1
	For P: $25\left(\frac{T+55}{2}\right)=800$	M1 A1
	solving for T: $T=9$	**DM1** A1
		(8) **[12]**
6 (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
	$4.9t^2-21t+19=0$	
	$t=\dfrac{21\pm\sqrt{21^2-4\text{x}4.9\text{x}19}}{9.8}$	
	$t=2.99$ or 3.0	DM1 A1
	$t=1.30$ or 1.3	A1
		(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]**

Question number	Scheme	Marks
7 (a)		
	$M(A)$ $\quad 8g \times 0.8 + 12g \times 1.2 = X \times 2.4$	M1 A1
	$X \approx 85$ (N) $\quad$ accept 84.9, $\frac{26g}{3}$	DM1 A1
		(4)
(b)		
	$R(\uparrow)$ $\quad \underline{(X+10)} + \underline{X} = 8g + 12g$	M1 <u>B1</u> A1
	$(X = 93)$	
	$M(A)$ $\quad 8g \times 0.8 + 12g \times x = X \times 2.4$	M1 A1
	$x = 1.4$ (m) $\quad$ accept 1.36	A1
		(6)
		[10]

Question number	Scheme	Marks
8 (a)	$\mathbf{v} = \dfrac{21\mathbf{i}+10\mathbf{j}-(9\mathbf{i}-6\mathbf{j})}{4} = 3\mathbf{i}+4\mathbf{j}$	M1 A1
	speed is $\sqrt{(3^2+4^2)} = 5\ (\text{km h}^{-1})$	M1 A1
		(4)
(b)	$\tan\theta = \dfrac{3}{4}\ (\Rightarrow \theta \approx 36.9°)$	M1
	bearing is 37, 36.9, 36.87, …	A1
		(2)
(c)	$\mathbf{s} = 9\mathbf{i}-6\mathbf{j}+t(3\mathbf{i}+4\mathbf{j})$	M1
	$= (3t+9)\mathbf{i}+(4t-6)\mathbf{j}$ ∗ cso	A1
		(2)
(d)	Position vector of S relative to L is	
	$(3T+9)\mathbf{i}+(4T-6)\mathbf{j}-(18\mathbf{i}+6\mathbf{j}) = (3T-9)\mathbf{i}+(4T-12)\mathbf{j}$	M1 A1
	$(3T-9)^2+(4T-12)^2 = 100$	M1
	$25T^2-150T+125=0$ or equivalent	DM1 A1
	$(T^2-6T+5=0)$	
	$T = 1, 5$	A1
		(6)
		[14]

Examiner reports

Question 1

The vast majority of candidates wrote down an appropriate equation for 'conservation of linear momentum' in part (a) and proceeded to calculate the required speed. Although there were occasional sign errors, numerical slips or miscopying errors, these were fairly rare and most candidates achieved the correct answer. Equating equal but opposite impulses was an alternative valid approach but was seldom seen. In part (b), most knew a correct formula for 'impulse' in terms of change in momentum on one particle, but often the direction was not properly accounted for; this often led to a negative value for 'm' (with the minus sign just being dropped 'because mass has to be positive'). If the impulse on particle B was used, a correct value for the velocity from part (a) was required to be eligible for accuracy marks. Sometimes, a correct formula was quoted but 'm' (rather than the relevant '$2m$' or '$5m$') was used as the mass. Occasionally 'mg' was quoted in the momentum expressions; this was not penalised in part (a) if the 'g' cancelled throughout, but it was treated as a method error in part (b).

Question 2

This question, particularly part (b), proved to be a real discriminator with many failing to appreciate how internal and external forces work.

In part (a) the majority of candidates were able to use the whole system to calculate the value of the tension. However there were still some candidates who confused mass and weight on both sides of the equation.

The second part was much more problematic with many candidates not knowing which forces to include in their equation and of those that did, a significant number lost a mark by giving the final answer to 4 significant figures.

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

A large number of entirely (or almost) correct solutions were seen to this question. Most candidates drew their velocity-time graphs correctly and included appropriate annotations, with the most common error being that the lines drawn did not cross. This did not deny candidates access to full marks in the rest of the question though and many went on to solve the problem correctly. Most realised that they needed to equate the expressions for area under the graph to 800 for both P and Q. Attempts to use constant acceleration formulae over the whole distance were occasionally seen and scored no marks although a few used this approach in a valid way for the separate parts of the motion. Most commonly, a combination of rectangles and triangles were used to represent area rather than the area of a trapezium which made the subsequent algebra more difficult, and there were occasional errors seen in simplification. A relatively common error was to calculate a correct time for Q ($t = 30$) but to misinterpret this as the time when they both came to rest leading to errors in the motion of P.

Question 6

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 7

Part (a) was well done by many who produced and solved an appropriate moments equation, although a minority thought that the two tensions were equal and 'solved' the problem by a vertical resolution. The second part proved to be more demanding, with those candidates who tried to use the value of the tension from part (a) scoring very little. Most resolved vertically and took moments about a point. There were occasional errors in the relevant lengths or omission of g and some candidates interpreted the tensions as T and $10T$ rather than T and $T + 10$. Errors were more prevalent in the working of those who took moments about two points giving them simultaneous equations to solve.

Question 8

There was some confusion in parts (a), (b) and (c) over which vectors were velocities and which were displacements, with some even using acceleration. In the first part, many did not appreciate the distinction between velocity and speed and in part (b) many were unable to convert an appropriate angle into a bearing. The third part tended to be well-answered but a few used 'verification' at $t = 0$ and $t = 4$ and scored nothing. Part (d) was a good discriminator and the less able were often unable to make much progress. The majority of candidates who used Pythagoras to find the magnitude of the relative position vector and equated it to 10 scored at least 3/6 but many often lost the accuracy marks due to poor algebra. There were a number of other methods seen which used the fact that the lighthouse was on the path of the ship and that the speed of the ship was 5 km/h and these received full credit.

Statistics for M1 Practice Paper Silver Level S3

Qu	Max score	Modal score	Mean %	Mean score for students achieving grade: ALL	A*	A	B	C	D	E	U
1	6		74	4.46	5.55	5.27	4.81	4.45	4.08	3.54	2.11
2	6	3	66	3.95	5.02	4.65	4.07	3.67	3.28	2.73	1.76
3	8		71	5.67		7.19	5.90	4.78	3.61	2.58	1.42
4	7		71	4.95	6.71	6.37	5.66	4.97	3.93	2.68	1.18
5	12		68	8.19	11.41	10.67	8.82	7.43	6.20	5.03	3.43
6	12		64	7.65	10.60	10.03	8.44	7.05	5.75	4.53	2.67
7	10		59	5.94		8.61	6.73	5.26	3.69	2.48	1.06
8	14		56	7.77		10.85	7.13	5.36	4.28	3.19	1.39
	75		**64.77**	**48.58**	**39.29**	**63.64**	**51.56**	**42.97**	**34.82**	**26.76**	**15.02**