Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Bronze Level B2

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
74	68	61	54	47	41

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1. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given relative to a fixed origin O.*]

Two cars P and Q are moving on straight horizontal roads with constant velocities. The velocity of P is $(15\mathbf{i} + 20\mathbf{j})$ m s^{-1} and the velocity of Q is $(20\mathbf{i} - 5\mathbf{j})$ m s^{-1}

(*a*) Find the direction of motion of Q, giving your answer as a bearing to the nearest degree.

(3)

At time $t = 0$, the position vector of P is $400\mathbf{i}$ metres and the position vector of Q is $800\mathbf{j}$ metres. At time t seconds, the position vectors of P and Q are $\mathbf{p}$ metres and $\mathbf{q}$ metres respectively.

(*b*) Find an expression for

(i) $\mathbf{p}$ in terms of t,
(ii) $\mathbf{q}$ in terms of t.

(3)

(*c*) Find the position vector of Q when Q is due west of P.

(4)

June 2016

2.

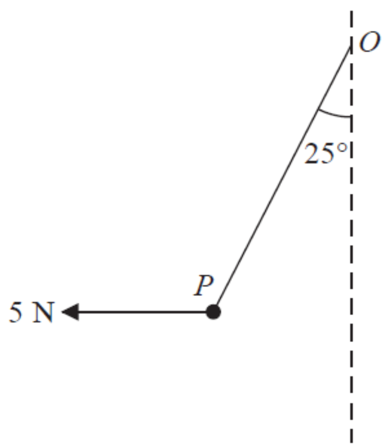

Figure 1

A particle P of weight W newtons is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point O. A horizontal force of magnitude 5 N is applied to P. The particle P is in equilibrium with the string taut and with OP making an angle of 25° to the downward vertical, as shown in Figure 1.

Find

(*a*) the tension in the string,

(3)

(*b*) the value of W.

(3)

June 2014 (R)

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3. A car of mass 1000 kg is towing a caravan of mass 750 kg along a straight horizontal road. The caravan is connected to the car by a tow-bar which is parallel to the direction of motion of the car and the caravan. The tow-bar is modelled as a light rod. The engine of the car provides a constant driving force of 3200 N. The resistances to the motion of the car and the caravan are modelled as constant forces of magnitude 800 newtons and R newtons respectively.

Given that the acceleration of the car and the caravan is 0.88 m s^{-2},

(*a*) show that $R = 860$,

(3)

(*b*) find the tension in the tow-bar.

(3)

January 2012

4.

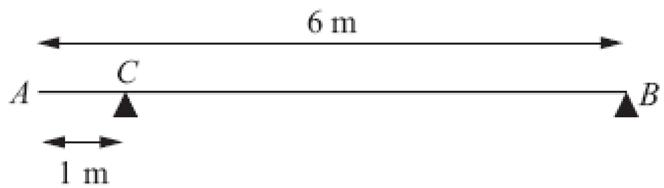

Figure 2

A uniform beam AB has mass 20 kg and length 6 m. The beam rests in equilibrium in a horizontal position on two smooth supports. One support is at C, where AC = 1 m, and the other is at the end B, as shown in Figure 2. The beam is modelled as a rod.

(*a*) Find the magnitudes of the reactions on the beam at B and at C.

(5)

A boy of mass 30 kg stands on the beam at the point D. The beam remains in equilibrium. The magnitudes of the reactions on the beam at B and at C are now equal. The boy is modelled as a particle.

(*b*) Find the distance AD.

(5)

January 2011

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5. A lifeboat slides down a straight ramp inclined at an angle of 15° to the horizontal. The lifeboat has mass 800 kg and the length of the ramp is 50 m. The lifeboat is released from rest at the top of the ramp and is moving with a speed of 12.6 m s^{-1} when it reaches the end of the ramp. By modelling the lifeboat as a particle and the ramp as a rough inclined plane, find the coefficient of friction between the lifeboat and the ramp.

(9)

January 2013

6.

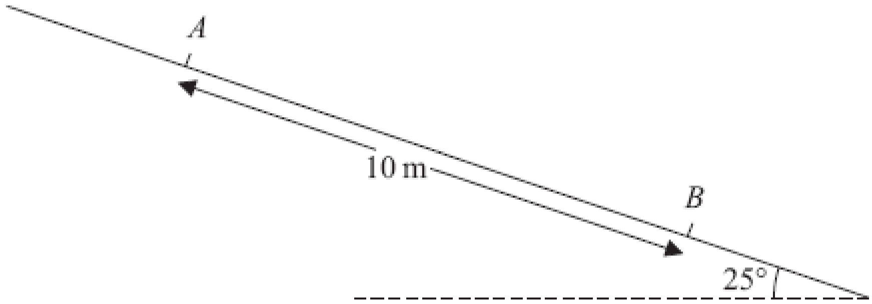

Figure 3

A particle P of mass 0.6 kg slides with constant acceleration down a line of greatest slope of a rough plane, which is inclined at 25° to the horizontal. The particle passes through two points A and B, where AB = 10 m, as shown in Figure 3. The speed of P at A is 2 m s^{-1}. The particle P takes 3.5 s to move from A to B.

Find

(*a*) the speed of P at B,

(3)

(*b*) the acceleration of P,

(2)

(*c*) the coefficient of friction between P and the plane.

(5)

May 2013 (R)

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7. A car moves along a straight horizontal road from a point A to a point B, where $AB = 885$ m. The car accelerates from rest at A to a speed of 15 m s^{-1} at a constant rate a m s^{-2}.

The time for which the car accelerates is $\frac{1}{3}T$ seconds. The car maintains the speed of 15 m s^{-1} for T seconds. The car then decelerates at a constant rate of 2.5 m s^{-2}, stopping at B.

(*a*) Find the time for which the car decelerates.
(2)

(*b*) Sketch a speed-time graph for the motion of the car.
(2)

(*c*) Find the value of T.
(4)

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

(*e*) Sketch an acceleration-time graph for the motion of the car.
(3)

January 2012

8.

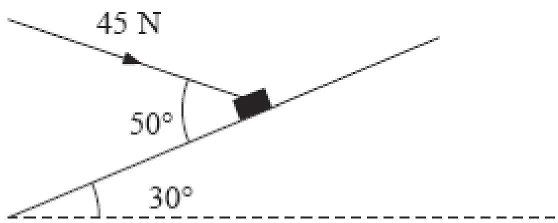


Figure 3

A package of mass 4 kg lies on a rough plane inclined at 30° to the horizontal. The package is held in equilibrium by a force of magnitude 45 N acting at an angle of 50° to the plane, as shown in Figure 3. The force is acting in a vertical plane through a line of greatest slope of the plane. The package is in equilibrium on the point of moving up the plane. The package is modelled as a particle. Find

(*a*) the magnitude of the normal reaction of the plane on the package,
(5)

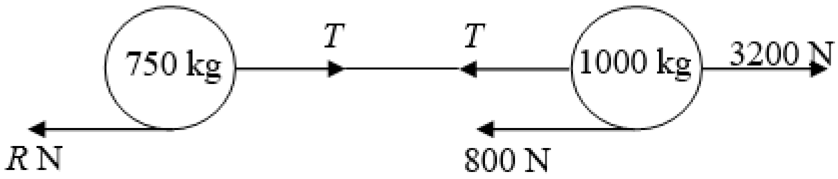
(*b*) the coefficient of friction between the plane and the package.
(6)

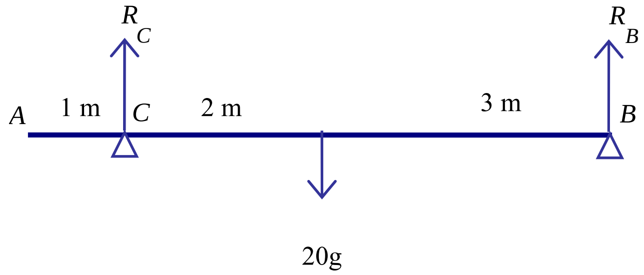
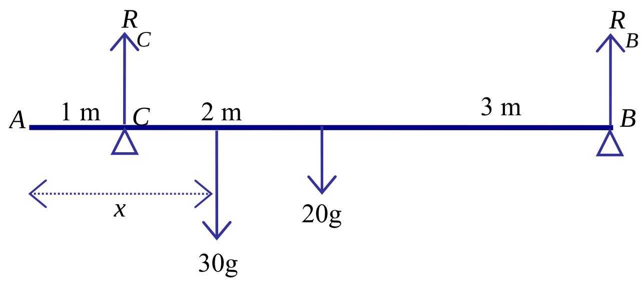
June 2008

TOTAL FOR PAPER: 75 MARKS

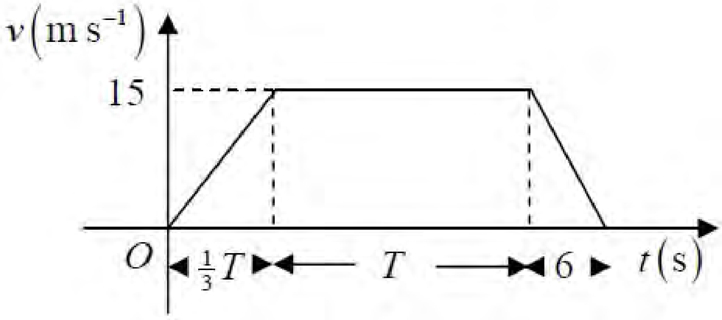
END

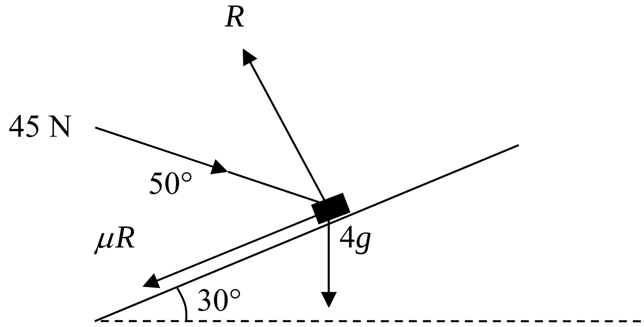
Question number	Scheme	Marks
1 (a)	$\tan\theta = \frac{5}{20}$	M1
	$\theta = 14.036..^0$	A1
	$\theta = 104^0$ nearest degree	A1
		(3)
(b)	$\mathbf{p} = 400\mathbf{i} + t(15\mathbf{i} + 20\mathbf{j})$	M1 A1
	$\mathbf{q} = 800\mathbf{j} + t(20\mathbf{i} - 5\mathbf{j})$	A1
		(3)
(c)	Equate their **j** components: $20t(\mathbf{j}) = (800 - 5t)(\mathbf{j})$	M1
	$t = 32$	A1
	$\mathbf{s} = 800\mathbf{j} + 32(20\mathbf{i} - 5\mathbf{j})$	M1
	$= 640\mathbf{i} + 640\mathbf{j}$	A1
		(4)
		[10]
2 (a)	Resolving horizontally: $5 = T\cos 65°$	M1A1
	$T =$ 12, 11.8, or better (N)	A1
		(3)
(b)	Resolving vertically: $W = T\cos 25°$	M1A1
	$= 11.8\cos 25° =$ 11, 10.7 or better (N)	A1
		(3)
		[6]

Question number	Scheme	Marks
3 (a)		
	For the whole system	
	R$(\rightarrow)$ $\quad 3200 - 800 - R = 1750 \times 0.88$	M1 A1
	Leading to $\quad R = 860$ ∗	A1
		(3)
(b)	For the caravan	
	R$(\rightarrow)$ $\quad T - 860 = 750 \times 0.88$	M1 A1
	Leading to $\quad T = 1520$ (N)	A1
		(3)
		[6]

Question number	Scheme	Marks
4 (a)		
	Taking moments about B: 5 x R_C = 20g x 3	M1A1
	R_C = 12g or 60g/5 or 118 or 120	A1
	Resolving vertically: $R_C + R_B = 20g$	M1
	$R_B = 8g$ or 78.4 or 78	A1
		(5)
(b)		
	Resolving vertically: 50g = R + R	B1
	Taking moments about B:	
	$5\times 25g = 3\times 20g + (6-x)\times 30g$	M1 A1 A1
	$30x = 115$	
	x = 3.8 or better or 23/6 oe	A1
		(5)
		[10]

Question number	Scheme	Marks
5	$12.6^2 = 2a.50 \qquad (\Rightarrow\ a = 1.5876)$ $800g\sin 15 - F = 800a$ $R = 800g\cos 15$ $F = \mu R$ $800g\sin 15 - \mu 800g\cos 15 = 800 \text{ x } 1.5876$ $\mu = 0.1, 0.10, 0.100$	M1 A1 M1 A1 M1 A1 B1 M1 A1 **[9]**
6 (a)	$s = \frac{u+v}{2}t \qquad 10 = \frac{2+v}{2} \times 3.5$ $v = \frac{20}{3.5} - 2 = \frac{26}{7} = 3.71 \quad (\text{m s}^{-1})$	M1A1 A1 **(3)**
(b)	$a = \frac{v-u}{t} = \frac{\frac{26}{7} - 2}{3.5} = \frac{24}{49} = 0.490 \ (\text{m s}^{-2})$	M1A1 **(2)**
(c)	Normal reaction : $R = 0.6g\cos 25°$ Resolve parallel to the slope : $0.6g\sin 25° - \mu \times R = 0.6 \times a$ $\mu = 0.41 \text{ or } 0.411$	B1 M1A2 A1 **(5)** **[10]**

Question number	Scheme		Marks
7 (a)	$v = u + at \Rightarrow 0 = 15 - 2.5t$		M1
	$t = 6 \quad (\text{s})$		A1
			(2)
(b)			
		Shape	B1
		15, T	B1
			(2)
(c)	$\frac{1}{2}15\left(\frac{4}{3}T + 6 + T\right) = 885$	ft their 6	M1 A1ft
	$\frac{7}{3}T = 118 - 6$		
	$T = 112 \times \frac{3}{7} = 48$		M1 A1
			(4)
(d)	$a = \frac{15}{\frac{1}{3}T} = \frac{15}{16}$,0.9375, 0.938, 0.94		M1 A1
			(2)
(e)		3 horizontal lines	B1
		Correctly placed;no cts vert line	B1
		-2.5 , ft their $\frac{15}{16}$	B1
			(3) **[13]**

Question number	Scheme	Marks
8 (a)		
	$R = 45\cos 40° + 4g\cos 30°$	M1 A2, 1, 0
	$R \approx 68$ accept 68.4	M1 A1
		(5)
(b)	Use of $F = \mu R$	M1
	$F + 4g\sin 30 = 45\cos 50°$	M1 A2, 1, 0
	Leading to $\mu \approx 0.14$ accept 0.136	M1 A1
		(6)
		[11]

Examiner reports

Question 1
This question was generally well answered by almost all candidates, particularly parts (a) and (b), where errors were few and far between. Some found the direction of P instead of the direction of Q and some were unable to convert their angle into a bearing. The final part was more inconsistent with some candidates getting confused as to which components to equate. A popular alternative approach was to find the vector **PQ** and then equate the **j**-coefficient of this vector to zero. A number of candidates did not complete part (c), having successfully obtained $t = 32$, they then failed to substitute this back in to find the position vector of Q as required.

Question 2
This question proved to be an easy starter for the vast majority of students. Most chose to resolve parallel and perpendicular to the slope and achieved the correct answers. Because g was not involved, there was no upper limit to the accuracy of the answers but we were expecting at least 2 significant figures.

Question 3
In the first part, the majority of candidates wrote down a correct equation of motion for the 'whole system' which they successfully solved to derive the given value for the resistance force on the caravan. Some chose to consider the car and caravan separately, calculating the tension from the car equation and then using this value in the caravan equation, again generally successfully. There were more errors evident in finding the tension in part (b); the mass used in the '*ma*' term was not always consistent with the rest of the equation and occasionally the mass of the whole system was used in an equation relating only to one body. Sometimes the two resistances were confused, two tensions were added together in one equation or the '*ma*' term was omitted completely, showing a lack of understanding of the motion of connected particles. Less significant errors tended to involve wrong signs. Overall, however, this question was very well done with full marks often awarded.

Question 4
The first part was done well, with the most common error being to give R_C as 117.6 N which was penalised for being over-accurate. The question required two equations and those who used a vertical resolution were almost always successful whereas those who used two moments equations often made errors. The same was true in part (b), but candidates often made errors when expressing the distances used in terms of AD. The omission of g was penalised in the first part but not in part (b), provided it was consistent, where it was not needed to obtain a fully correct solution. A few used the same values for the reactions in part (b) as those found in the first part and received little credit.

Question 5
Candidates seemed to like this question and there were many correct solutions. Most candidates found the acceleration successfully using *suvat* but some treated the whole question as a statics problem. Others omitted the weight component when resolving along the plane and a few used 30° instead of 15°. Occasionally sine and cosine were mixed up when resolving but for the most part the candidates produced convincing solutions.

Question 6
The first two parts of this question were generally answered very well with the appropriate *suvat* equations usually being used correctly. It was not uncommon to see the answer for the acceleration in part (b) appearing first and then it being used to find the velocity in the first part. There were more problems with the final part where the main error was forgetting to include the component of the weight when resolving parallel to the plane.

Question 7
In the first part, the majority of candidates found the required time in a valid way, although occasionally substitution into '$v = u + at$' without regard to sign (or interchanging u and v) led to '$t = -6$' and a subsequent change to '$t = 6$' without explanation.

In part (b), the vast majority produced a speed-time graph of the correct shape (a trapezium starting and finishing on the t-axis), but some failed to mark the 'T' correctly (often leading to the interval for the constant speed part of the graph being $\frac{2}{3}T$ rather than T). In the third part, most attempted to equate the area under the graph to the given distance, either using the trapezium formula or splitting into triangles and a rectangle; sometimes, however, there were errors in identifying the relevant lengths in terms of T. Attempts to apply constant acceleration formulae inappropriately to the whole distance were only very rarely seen. Most candidates evaluated the gradient in part (d) to find the acceleration as required, but those who were using an incorrect value for T could only achieve one of the two available marks. The acceleration-time graph in the final part was generally drawn correctly with three separate horizontal sections. Marks lost tended to be from not labelling the known values of the acceleration (or writing '2.5' rather than '−2.5' on the negative acceleration axis) or from using continuous vertical lines to join the sections. Nevertheless, a significant number of full marks were seen with most candidates scoring well.

Question 8
It was good to see so many fully correct solutions to this question which was best solved by resolving parallel and perpendicular to the plane. Only the weakest candidates failed to include all the relevant forces. Those candidates who attempted vertical and horizontal resolution often fell victim to inaccuracies in angles or more costly, to missing forces. Since g = 9.8 had been used, the final mark in part (a) was often lost for an answer of 68.42. Virtually all tried to use $F = \mu R$ appropriately in part (b) although occasionally F was acting in the wrong direction. Other errors in both parts included incorrect signs, confusion over which angles to use and sine/cosine applied the wrong way round.

Statistics for M1 Practice Paper Bronze Level B2

				Mean score for students achieving grade:							
Qu	**Max score**	**Modal score**	**Mean %**	**ALL**	**A***	**A**	**B**	**C**	**D**	**E**	**U**
1	10	10	78	7.80	9.59	9.29	8.38	7.51	6.42	5.23	3.03
2	6		88	5.26	5.87	5.79	5.51	5.09	4.35	4.61	1.61
3	6		81	4.84	5.82	5.68	5.02	4.32	3.48	2.89	1.56
4	10		76	7.64	9.25	9.03	7.80	6.10	4.94	3.48	1.31
5	9	9	83	7.48	8.72	8.52	7.68	7.04	6.31	4.93	3.35
6	10		79	7.93	9.63	8.99	8.05	7.11	5.77	6.05	3.75
7	13		77	9.99	12.11	11.72	10.31	9.08	7.76	6.88	4.58
8	11		70	7.75		10.11	9.01	7.68	5.93	4.42	1.91
	75		**78.25**	**58.69**	**60.99**	**69.13**	**61.76**	**53.93**	**44.96**	**38.49**	**21.10**