Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Bronze Level B1

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 7 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	62	55	48	51

1. Two particles B and C have mass m kg and 3 kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table. The two particles collide directly. Immediately before the collision, the speed of B is 4 m s^{-1} and the speed of C is 2 m s^{-1}. In the collision the direction of motion of C is reversed and the direction of motion of B is unchanged. Immediately after the collision, the speed of B is 1 m s^{-1} and the speed of C is 3 m s^{-1}.

Find

(*a*) the value of m,

(3)

(*b*) the magnitude of the impulse received by C.

(2)

January 2011

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2. An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of 8 m s^{-1}. This speed is then maintained for T seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 s.

(*a*) Sketch a speed-time graph to illustrate the motion of the athlete.

(3)

(*b*) Calculate the value of T.

(5)

January 2010

3.

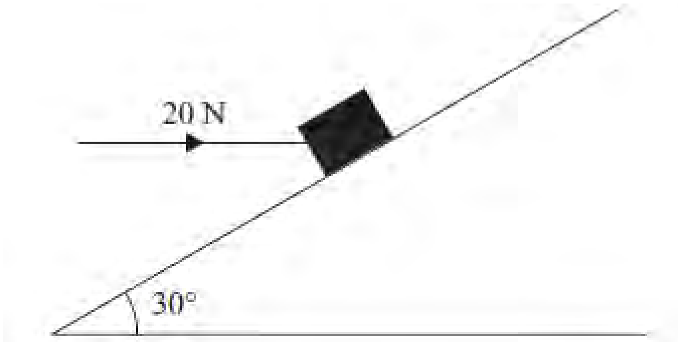

Figure 1

A box of mass 5 kg lies on a rough plane inclined at 30° to the horizontal. The box is held in equilibrium by a horizontal force of magnitude 20 N, as shown in Figure 1. The force acts in a vertical plane containing a line of greatest slope of the inclined plane.

The box is in equilibrium and on the point of moving down the plane. The box is modelled as a particle.

Find

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

(4)

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

(5)

May 2012

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

A ship S is moving with constant velocity (3**i** + 3**j**) km h^{-1}. At time $t = 0$, the position vector of S is (–4**i** + 2**j**) km.

(*a*) Find the position vector of S at time t hours.

(2)

A ship T is moving with constant velocity (–2**i** + n**j**) km h^{-1}. At time $t = 0$, the position vector of T is (6**i** + **j**) km. The two ships meet at the point P.

(*b*) Find the value of n.

(5)

(*c*) Find the distance OP.

(4)

May 2013 (R)

5.

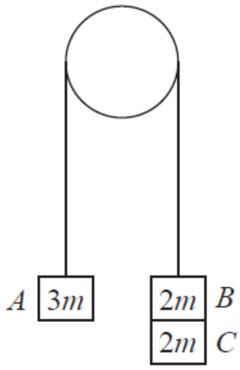


Figure 2

Three particles *A*, *B* and *C* have masses 3*m*, 2*m* and 2*m* respectively. Particle *C* is attached to particle *B*. Particles *A* and *B* are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 2. The system is released from rest and *A* moves upwards.

(*a*) (i) Show that the acceleration of *A* is $\frac{g}{7}$.

(ii) Find the tension in the string as *A* ascends.

(7)

At the instant when *A* is 0.7 m above its original position, *C* separates from *B* and falls away. In the subsequent motion, *A* does not reach the pulley.

(*b*) Find the speed of *A* at the instant when it is 0.7 m above its original position.

(2)

(*c*) Find the acceleration of *A* at the instant after *C* separates from *B*.

(4)

(*d*) Find the greatest height reached by *A* above its original position.

(3)

June 2014

6.

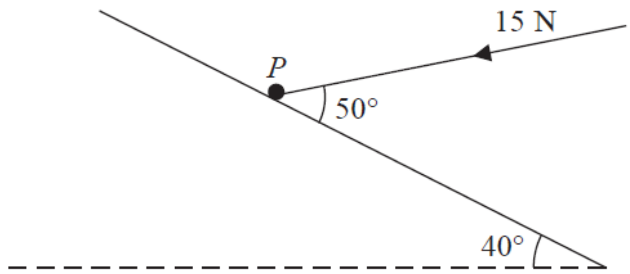


Figure 3

A particle P of mass 2.7 kg lies on a rough plane inclined at 40° to the horizontal. The particle is held in equilibrium by a force of magnitude 15 N acting at an angle of 50° to the plane, as shown in Figure 3. The force acts in a vertical plane containing a line of greatest slope of the plane. The particle is in equilibrium and is on the point of sliding down the plane.

Find

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

(4)

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

(5)

The force of magnitude 15 N is removed.

(*c*) Determine whether P moves, justifying your answer.

(4)

June 2014 (R)

7.

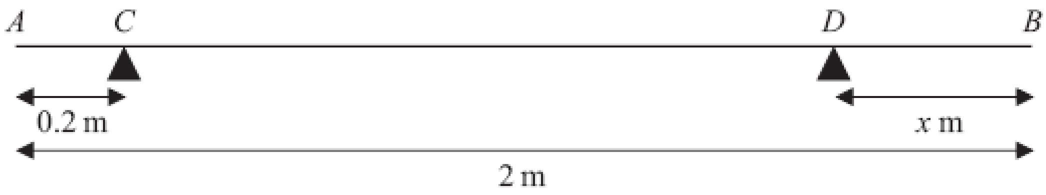


Figure 4

A uniform rod AB has length 2 m and mass 50 kg. The rod is in equilibrium in a horizontal position, resting on two smooth supports at C and D, where $AC = 0.2$ metres and $DB = x$ metres, as shown in Figure 4. Given that the magnitude of the reaction on the rod at D is twice the magnitude of the reaction on the rod at C,

(*a*) find the value of x.

(6)

The support at D is now moved to the point E on the rod, where $EB = 0.4$ metres. A particle of mass m kg is placed on the rod at B, and the rod remains in equilibrium in a horizontal position. Given that the magnitude of the reaction on the rod at E is four times the magnitude of the reaction on the rod at C,

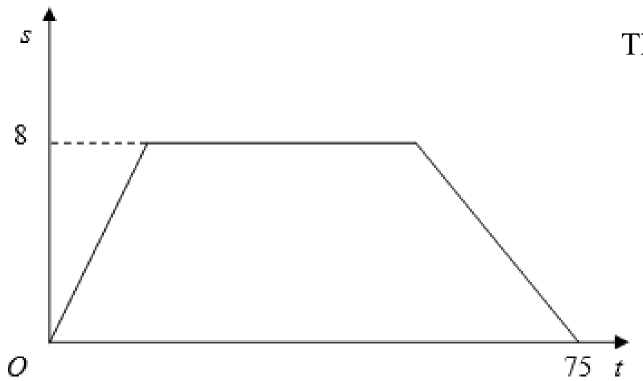
(*b*) find the value of m.

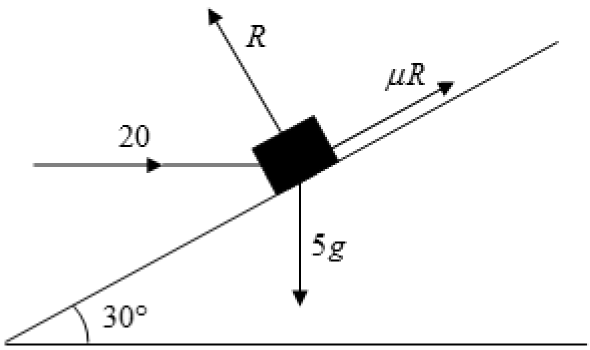
(7)

May 2013 (R)

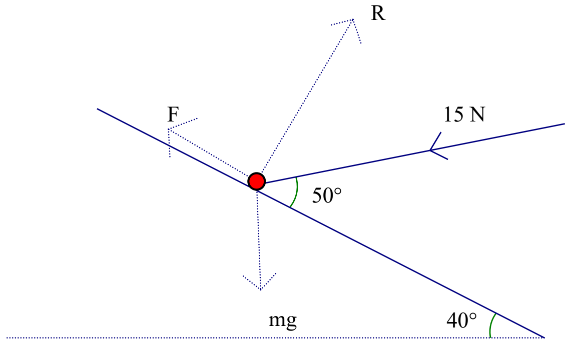
TOTAL FOR PAPER: 75 MARKS

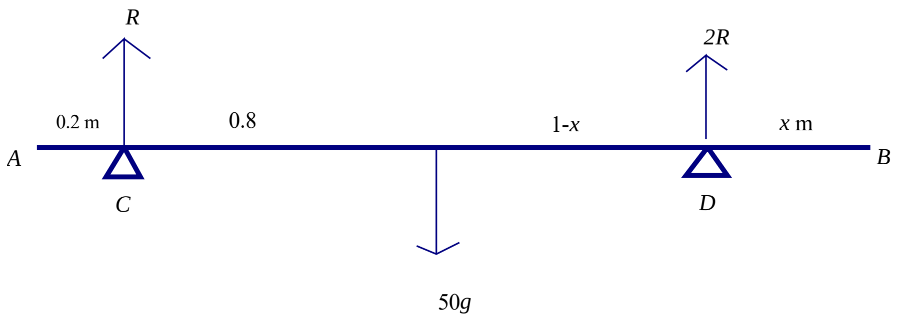
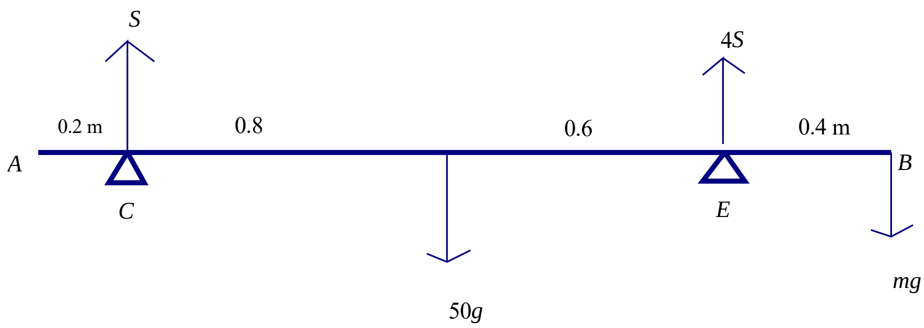
END

Question number	Scheme	Marks
1 (a)	Conservation of momentum: $4m - 6 = m + 9$ $m = 5$	 M1 A1 A1 **(3)**
(b)	Impulse = change in momentum $= 3 \times 3 - (3 \times -2) = 15$	 M1 A1 **(2)** **[5]**
2 (a)	First two line segments Third line segment 8, 75  	B1 B1 B1 **(3)**
(b)	$\frac{1}{2} \times 8 \times (T + 75) = 500$ Solving to $T = 50$	M1 A2 (1,0) DM1 A1 **(5)** **[8]**

Question number	Scheme	Marks
3		
(a)	$\perp$ plane $R = 20\cos 60° + 5g\cos 30°$	M1 A2(1,0)
	$= 52.4\ (\text{N})$ or 52	A1
		(4)
(b)	$F_r = \mu R$	B1
	plane $F + 20\cos 30° = 5g\cos 60°$	M1 A2(1, 0)
	Leading to $\mu = 0.137$ or 0.14	A1
		(5)
		[9]
4 (a)	Use of $\mathbf{r} = \mathbf{r}_0 + \mathbf{v}t$	M1
	$(-4\mathbf{i} + 2\mathbf{j}) + (3\mathbf{i} + 3\mathbf{j})t = (-4 + 3t)\mathbf{i} + (2 + 3t)\mathbf{j}$	A1
		(2)
(b)	$(6\mathbf{i} + \mathbf{j}) + (-2\mathbf{i} + n\mathbf{j})t = (6 - 2t)\mathbf{i} + (1 + nt)\mathbf{j}$	B1
	Position vectors identical $\Rightarrow -4 + 3t = 6 - 2t$ **AND** $5t = 10$,	M1
	Either equation	A1
	$2 + 3\times 2 = 1 + 2n$,	**DM1**
	$n = 3.5$	A1
		(5)
(c)	Position vector of P is $(-4+6)\mathbf{i} + (2+6)\mathbf{j} = 2\mathbf{i} + 8\mathbf{j}$	M1A1
	Distance OP $= \sqrt{2^2 + 8^2} = \sqrt{68} = 8.25\ (\text{km})$	M1A1
		(4)
		[11]

Question number	Scheme	Marks
5 (a)	$4mg - T = 4ma$	M1A1
	$T - 3mg = 3ma$	M1A1
	Condone the use of $4mg - 3mg = 4ma + 3ma$ in place of one of these equations.	M1A1
	Reach **given answer** $a = \frac{g}{7}$ correctly ***	A1
	Form an equation in T:	
	$T = 3mg + 3\left(mg - \frac{T}{4}\right)$, $T = 3mg + 3m\frac{g}{7}$, or $T = 4mg - 4m\frac{g}{7}$	M1
	$T = \frac{24}{7}mg$ or equivalent, 33.6m, 34m	A1
		(7)
(b)	$v^2 = u^2 + 2as = 2 \times \frac{g}{7} \times 0.7 = 1.96$, $v = 1.4$ ms^{-1}	M1A1
		(2)
(c)	$3mg - T = 3ma$	M1A1
	$T - 2mg = 2ma$	A1
	$a = \frac{g}{5}$	A1
		(4)
(d)	$0 = 1.96 - 2 \times \frac{g}{5} \times s$	M1
	$s = \frac{5 \times 1.96}{2g} = 0.5$ (m)	A1
	Total height = $0.7 + 0.5 = 1.2$ (m)	A1 **ft**
		(3)
		[16]

Question number	Scheme	Marks
6 (a)		
	Perpendicular to the slope: $R = 2.7g\cos 40 + 15\cos 40$	M1A2
	$= 31.8$ (N) or 32 (N)	A1
		(4)
(b)	Parallel to the slope: $F = 2.7g\sin 40 - 15\cos 50$ $\quad (F = 7.366..)$	M1A2
	Use of $F = \mu R$	M1
	$\mu = \dfrac{2.7g\sin 40 - 15\cos 50}{R} = 0.23$ or 0.232	A1
		(5)
(c)	Component of wt parallel to slope = $2.7g\sin 40°$ $(= 17.0)$	B1
	$F_{max} = 0.232 \times 2.7 \times g \times \cos 40° = 4.7...$ (N)	M1A1
	$17.0 > 4.70$ so the particle moves	A1
		(4)
		[13]

Question number	Scheme	Marks
7 (a)		
	Vertical equilibrium: $R + 2R = 50g$,	M1A1
	Moments about C: $50g \times 0.8 = (1.8 - x) \times 2 \times R$	M1A1
	$3 \times 0.8 = 3.6 - 2x$, $x = 0.6$	**DM1**A1
		(6)
(b)		
	S, $4S$	B1
	Vertical equilibrium: $S + 4S = (50 + m)g = 5S$	M1A1
	Moments about B: $50g \times 1 = 4S \times 0.4 + S \times 1.8 = 3.4S$	M1A1
	$50 \times \frac{5}{3.4} = (50 + m)$	**DM1**
	m = 400/17, 24, 23.5 or better	A1
		(7)
		[13]

Examiner reports

Question 1

This provided a very straightforward start for most candidates. In part (a), nearly all used an appropriate conservation of linear momentum equation and sign errors due to incorrect interpretation of directions were comparatively rare. Occasionally attempts to equate impulses were seen; these were acceptable provided it was recognised that they were in opposite directions. The majority used impulse = change in momentum in part (b), generally with appropriate signs, although 3(3 – 2) was sometimes seen. The marks could be achieved by considering either particle, but one of them depended on a correct value of m from part (a). Most remembered to give the magnitude as (+)15 for the final mark.

Question 2

In part (a) the speed-time graph was almost universally correct. Most candidates realised, in the second part, that the area under the graph was equal to the distance travelled and were able to calculate the correct area of 20 for the first part of the motion. Errors in the interpretation of T caused most of the problems in the calculations of the other areas. Comparatively few used an area of a trapezium which provided the neatest solution.

Question 3

This was a well-answered question. The majority of candidates obtained the correct number of terms in the resolutions and were able to resolve properly, with most candidates making sensible choices of the methods to use. Common errors were due to wrong signs, specifically with the 20 component, or missing g. There were also a few instances of division by sin or cos or the use of tan. A few candidates also neglected the weight in their resolving. The vast majority of candidates opted to resolve perpendicular and parallel to the plane. Of the few who chose to resolve horizontally and vertically most were successful but a few left out a component. There were surprisingly many candidates who lost the final mark through over-accuracy.

Virtually all candidates gained the mark for the use of $F = \mu R$. A significant number did not realise that friction acted up the plane and the ensuing negative value for μ was then conveniently lost. It seemed that fewer candidates than in previous years made the mistake of using $g = 9.81$.

There was evidence of a few candidates having their calculators set in radians rather than in degrees.

Question 4

This was a straightforward vector question with the vast majority of candidates who attempted it scoring full marks. Those who were unsure what to do usually were able to score the first three marks for the position vectors of S and T. In part (b) a few were confused about which components to equate and lost marks if they didn't equate both and in the final part some obtained the correct position vector for P but then forgot to calculate the appropriate distance.

Question 5
This question was well answered by the majority of students. In part (a) most identified correctly individual equations of motion for the two masses and then solved them simultaneously to find the acceleration. Since the answer was given, any potential sign errors tended to be rectified but occasionally the answer did not strictly follow from the working. Sometimes the values '3' and '4' were used rather than '$3m$' and '$4m$' as given in the question. This was penalised as accuracy errors here, but all subsequent marks for the rest of the question were available. The most common error in finding the tension was to omit 'm' in the final answer despite it being included in the working.

In the second part virtually all students found the velocity correctly by using '$v^2 = u^2 + 2as$'; the only significant error seen was in using 'g' rather than '$g/7$' showing a lack of understanding of the situation.

Part (c) required a similar approach to part (a) but with one different mass. Since the answer was not given this time, there were some arithmetic and sign errors, but generally it was well done. Those who used a value of the tension from part (a) achieved no credit, as did those who tried to somehow use constant acceleration formulae.

The majority of students used an appropriate constant acceleration formula in the final part to find the maximum height reached, using the values of velocity and acceleration from previous parts of the question. Occasionally '$g/7$' or 'g' were used, again showing a lack of understanding of the mechanics. Most, but not all, added '0.7' from the initial part of the motion to reach the final answer as required.

Full marks for this question were often achieved and much good working was seen.

Question 6
Part (a) there were a few errors with angles and some sin/cos confusion but generally this was well done. Most marks lost were due to over-accuracy of the answer after use of $g = 9.8$.

There were some sign errors in the second part but most students were able to make a good attempt at finding a value for μ. Part (c) most were able to find the component of the weight down the plane but many lost the rest of marks by using the original value of the friction. Also a good number of answer marks were lost due to the use of a rounded value of μ which gave a value of 4.66 N instead of 4.70 N for the limiting friction force.

Question 7
Part (a) was a relatively straightforward question where the majority of candidates scored full marks. Resolving vertically and taking moments once, usually about *C*, was by far the most popular approach but a few opted to take moments twice and this inevitably made it more difficult. In the second part again many candidates scored full marks, with most resolving vertically and taking moments about *B*. Apart from the usual errors with distances in some of the moments equations, the other mistakes tended to be omitting the mg from the vertical resolution or using the reaction found in part (a).

Statistics for M1 Practice Paper Bronze Level B1

Qu	Max score	Modal score	Mean %	Mean score for students achieving grade: ALL	A*	A	B	C	D	E	U
1	5		88	4.38	4.85	4.75	4.45	4.12	3.73	3.40	2.17
2	8		86	6.87		7.54	7.04	6.45	5.87	5.28	4.21
3	9		78	7.06	8.72	8.52	7.90	7.17	6.23	4.95	2.53
4	11		82	9.01	10.94	10.43	9.82	8.12	6.18	5.75	3.74
5	16		72	11.50	15.10	14.38	12.76	11.02	9.03	6.67	3.18
6	13		74	9.63	11.69	10.76	9.85	8.90	7.60	5.82	3.03
7	13		81	10.53	12.59	12.32	11.39	9.59	7.46	6.52	3.82
	75		**78.64**	**58.98**	**63.89**	**68.70**	**63.21**	**55.37**	**46.10**	**38.39**	**22.68**