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

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
67	59	51	42	33	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)

May 2013 (R)

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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)

January 2011

3.

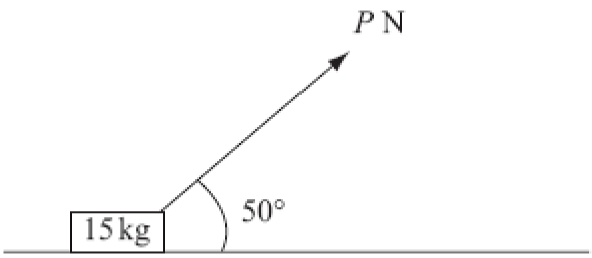

Figure 1

A small box of mass 15 kg rests on a rough horizontal plane. The coefficient of friction between the box and the plane is 0.2 . A force of magnitude P newtons is applied to the box at 50° to the horizontal, as shown in Figure 1. The box is on the point of sliding along the plane.

Find the value of P, giving your answer to 2 significant figures.

(9)

May 2009

4.

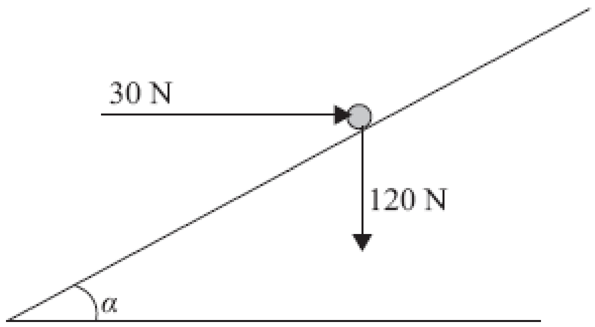

Figure 2

A particle of weight 120 N is placed on a fixed rough plane which is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$.

The coefficient of friction between the particle and the plane is $\frac{1}{2}$.

The particle is held at rest in equilibrium by a horizontal force of magnitude 30 N, which acts in the vertical plane containing the line of greatest slope of the plane through the particle, as shown in Figure 2.

(*a*) Show that the normal reaction between the particle and the plane has magnitude 114 N.
(4)

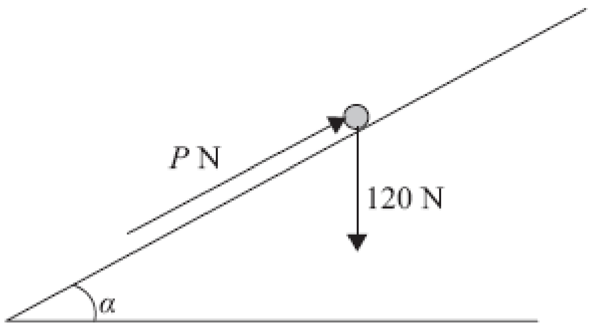

Figure 3

The horizontal force is removed and replaced by a force of magnitude P newtons acting up the slope along the line of greatest slope of the plane through the particle, as shown in Figure 3. The particle remains in equilibrium.

(*b*) Find the greatest possible value of P.
(8)

(*c*) Find the magnitude and direction of the frictional force acting on the particle when $P = 30$.
(3)

January 2011

5. A beam AB has length 15 m. The beam rests horizontally in equilibrium on two smooth supports at the points P and Q, where $AP = 2$ m and $QB = 3$ m. When a child of mass 50 kg stands on the beam at A, the beam remains in equilibrium and is on the point of tilting about P. When the same child of mass 50 kg stands on the beam at B, the beam remains in equilibrium and is on the point of tilting about Q. The child is modelled as a particle and the beam is modelled as a non-uniform rod.

(*a*) (i) Find the mass of the beam.

(ii) Find the distance of the centre of mass of the beam from A.

(8)

When the child stands at the point X on the beam, it remains horizontal and in equilibrium. Given that the reactions at the two supports are equal in magnitude,

(*b*) find AX.

(6)

May 2013

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6. [*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 with constant velocity $(-12\mathbf{i} + 7.5\mathbf{j})$ km h^{-1}.

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

(3)

At time t hours after noon, the position vector of S is $\mathbf{s}$ km. When $t = 0$, $\mathbf{s} = 40\mathbf{i} - 6\mathbf{j}$.

(*b*) Write down $\mathbf{s}$ in terms of t.

(2)

A fixed beacon B is at the point with position vector $(7\mathbf{i} + 12.5\mathbf{j})$ km.

(*c*) Find the distance of S from B when $t = 3$.

(4)

(*d*) Find the distance of S from B when S is due north of B.

(4)

May 2012

7.

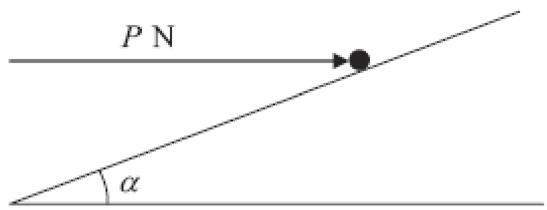


Figure 4

A particle of mass 0.4 kg is held at rest on a fixed rough plane by a horizontal force of magnitude P newtons. The force acts in the vertical plane containing the line of greatest slope of the inclined plane which passes through the particle. The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$, as shown in Figure 4.

The coefficient of friction between the particle and the plane is $\frac{1}{3}$.

Given that the particle is on the point of sliding up the plane, find

(*a*) the magnitude of the normal reaction between the particle and the plane,

(5)

(*b*) the value of P.

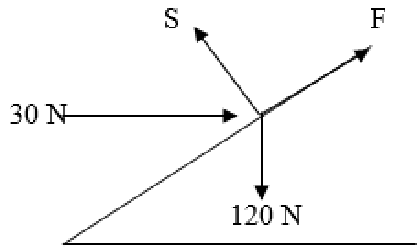
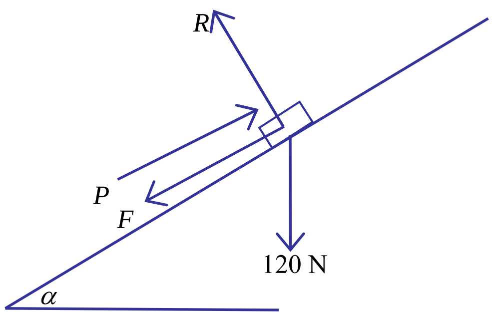
(5)

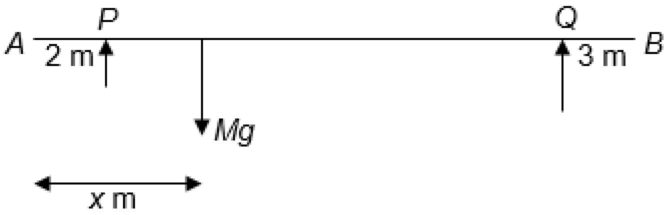
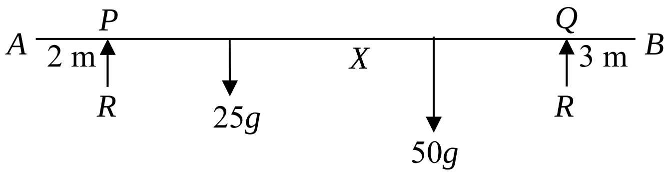
May 2010

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]**
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]
3	$F = P\cos 50^o$	M1 A1
	$F = 0.2R$ seen or implied.	B1
	$P\sin 50^o + R = 15g$	M1 A1 A1
	Eliminating R; Solving for P ; $P =$ 37 (2 SF)	M1; M1;A1
		[9]

Question number	Scheme	Marks
4 (a)		
	Resolving perpendicular to the plane:	
	$S = 120\cos\alpha + 30\sin\alpha$	M1 A1 A1
	$= 114$ *	A1
		(4)
(b)		
	Resolving perpendicular to the plane:	
	$R = 120\cos\alpha$	M1 A1
	$= 96$	A1
	$F_{max} = \frac{1}{2}R$	M1
	Resolving parallel to the plane:	
	In equilibrium: $P_{max} = F_{max} + 120\sin\alpha$	M1 A(2,1,0)
	$= 48 + 72 = 120$	A1
		(8)
(c)	$30 + F = 120\sin\alpha$ **OR** $30 - F = 120\sin\alpha$	M1 A1
	So $F = 42\text{N}$ acting up the plane.	A1
		(3)
		[15]

Question number	Scheme	Marks
5 (a)		
	M(P), $50g \times 2 = Mg \times (x-2)$	M1 A1
	M(Q), $50g \times 3 = Mg \times (12-x)$	M1 A1
(i)	$M = 25$ (kg)	**DM**1 A1
(ii)	$x = 6$ (m)	**DM**1 A1
		(8)
(b)		
	$(\uparrow) R + R = 25g + 50g$	M1 A1 **ft**
	M(A), $2R + 12R = 25g \times 6 + 50g \times AX$	M1 A1 **ft**
	$AX = 7.5$ (m)	**DM**1 A1
		(6)
		[14]

Question number	Scheme	Marks
6 (a)	$\arctan\frac{7.5}{12} = 32°$	M1 A1
	Bearing is 302 (allow more accuracy)	A1
		(3)
(b)	$\mathbf{s} = 40\mathbf{i} - 6\mathbf{j} + t(-12\mathbf{i} + 7.5\mathbf{j})$	M1 A1
		(2)
(c)	$t = 3$, $\quad \mathbf{s} = 4\mathbf{i} + 16.5\mathbf{j}$	M1
	$\mathbf{s} - \mathbf{b} = -3\mathbf{i} + 4\mathbf{j}$	M1
	$SB = \sqrt{\left((-3)^2 + 4^2\right)} = 5 \ (\text{km})$	DM1 A1
		(4)
(d)	Equating **i** components	
	$40 - 12t = 7$ **or** $-33 + 12t = 0$	M1
	$t = 2\frac{3}{4}$	A1
	When $t = 2\frac{3}{4}$, $\quad \mathbf{s} = (7\mathbf{i}) + 14\frac{5}{8}\mathbf{j}$	M1
	$SB = 2\frac{1}{8}\ (\text{km})$ 2.125, 2.13	A1
		(4)
		[13]
7 (a)	$F = \frac{1}{3}R$	B1
	$(\uparrow)\ R\cos\alpha - F\sin\alpha = 0.4g$	M1 A1
	$R = \frac{2}{3}g = 6.53$ or 6.5	M1 A1
		(5)
(b)	$(\rightarrow) P - F\cos\alpha - R\sin\alpha = 0$	M1 A2
	$P = \frac{26}{45}g = 5.66$ or 5.7	M1 A1
		(5)
		[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

Most candidates scored three marks for $F = P\cos 50°$ and for $F = 0.2R$. However, errors were often made in the vertical resolution, with some ignoring P completely, giving $R = 15g$, while others included a component of P but made a sign error. A small minority of candidates was unable to eliminate R legitimately between their equations, while a significant number lost the final A1 for giving the answer as 36.9 (or 36.93).

Question 4

Most candidates were able to resolve perpendicular to the plane, in part (a), to obtain a correct expression for the reaction. The given answer was exact so evidence of rounding, such as using a rounded value for the angle, was penalised. In the second part, some did not realise that they needed to find the new reaction and so lost a number of marks. Many did complete the resolutions correctly although occasionally the friction was acting up the slope instead of down. Attempts at part (c) tended to be less successful, with the weight component often omitted or else limiting friction was used. Those who found a correct numerical value for the magnitude of the frictional force (by resolving parallel to the plane) did not always deduce the correct direction.

Question 5

Many candidates struggled to produce a clear strategy for solving part (a) of this problem. Clear separate diagrams of the two situations (child at one end of the beam and then at the other) would have helped. Those who failed to recognise that the implication of 'on the point of tilting' is that one of the reactions is zero, could make no significant progress and this led to considerable wasted effort in trying to solve a variety of equations in too many unknowns. The most direct method of solution was, for each case, to take moments about the pivot with the non-zero reaction, leading to simultaneous equations in the required distance and mass. Often the unknown distance(s) were not made clear and sometimes the same letter was used to represent the distance to the centre of mass from whatever point a moment was taken about, for example, $50g \times 2 = mgx$ followed by $50g \times 3 = mgx$. If these two equations were added together and the fact that the sum of the two distances was 10 was used, the answer for m fell out. Another valid approach was to find the reaction (same in both situations) by vertical resolution and then use this in appropriate moments equations. However, it was not always obvious which points were being used, where the child was standing, or what unknown distances represented; lack of clarity made some work difficult to decipher with candidates writing down too many equations with a variety of unknowns (and often much crossing out). A number of fully correct solutions were seen, although some candidates penalised themselves by giving weight as their answer rather than mass, and/or giving the distance to the centre of mass from the wrong point. Although some candidates gave up before tackling the second part, this was generally attempted with a much greater degree of success. Those who carried forward incorrect answers from part (a) could achieve 5 out of the 6 available marks and many did so. Most candidates drew a diagram for the new situation and then followed the standard approach of resolving vertically to find the two equal reactions and then taking moments about a point (generally A or P). Those who had no values to carry forward from the first part could still achieve the method marks here.

Question 6

In part (a) since only the velocity was stated, virtually all candidates used this vector to identify a relevant angle (generally 32 or 58) using a correct 'arctan'. However, a significant number failed to derive the corresponding bearing (302). In the second part, most stated a correct position vector in terms of t, although occasionally the initial position was omitted or the two vectors were reversed. Part (c) required the substitution of $t = 3$ and the subtraction of the two position vectors. The majority substituted first and generally found a correct vector. However, some did not attempt to find the magnitude of the displacement to calculate the distance between B and S as required. Although in part (d) many candidates correctly equated **i** components to determine the time when S was due North of B, some either equated **j** components or, more commonly, equated to zero, the **i** component of the position vector of S. Those who reached a value for t generally substituted it into the position vector for S but sometimes left their final answer as '14.625' rather than subtracting 12.5 as required. Giving the final answer as '2.125**j**' rather than '2.125' was penalised. There were a large number of entirely correct solutions seen, but there were also a fair number of candidates who made little clear progress in part (d).

Question 7

This question proved to be a good discriminator. The most popular approach was to resolve parallel and perpendicular to the plane (rather than horizontally and vertically which was much easier and avoided having to use simultaneous equations). The majority of candidates used $F = \mu R$ appropriately. Some, however, just equated the reaction to a weight component thereby simplifying the equations considerably and losing a significant number of marks. Candidates who did set up simultaneous equations correctly sometimes had difficulty in solving them to find the correct values for R and P, with poor use of brackets and algebraic manipulation contributing to this. A fairly common error was to give R in terms of P instead of calculating a numerical value for it. The final answers were required to be rounded to 2 or 3 significant figures for consistency with the use of $g = 9.8$ but this was not always observed and incurred a one mark penalty for the question.

Statistics for M1 Practice Paper Silver Level S5

				Mean score for students achieving grade:							
Qu	**Max score**	**Modal score**	**Mean %**	**ALL**	**A***	**A**	**B**	**C**	**D**	**E**	**U**
1	6		73	4.37	5.45	4.90	4.25	3.73	3.39	3.42	2.53
2	8		63	5.03	6.82	6.02	4.87	3.89	3.09	2.63	1.58
3	9		67	6.01		8.05	6.87	5.75	4.48	3.25	1.37
4	15		73	11.01	13.83	13.17	11.50	9.34	6.96	4.96	1.80
5	14	0	43	6.03	12.12	10.61	6.62	4.18	2.51	1.43	0.41
6	13		67	8.69	12.40	11.80	10.00	8.07	6.25	4.44	1.96
7	10		60	6.02	9.07	8.37	6.93	5.50	4.08	2.69	1.04
	75		**62.88**	**47.16**	**59.69**	**62.92**	**51.04**	**40.46**	**30.76**	**22.82**	**10.69**