

Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Silver Level S2

Time: 1 hour 30 minutes

Materials required for examination

Mathematical Formulae (Green)

Items included with question papers

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
70	62	54	46	35	28

1. Two particles P and Q have masses $4m$ and m respectively. The particles are moving towards each other on a smooth horizontal plane and collide directly. The speeds of P and Q immediately before the collision are $2u$ and $5u$ respectively. Immediately after the collision, the speed of P is $\frac{1}{2}u$ and its direction of motion is reversed.

(a) Find the speed and direction of motion of Q after the collision. (4)

(b) Find the magnitude of the impulse exerted on P by Q in the collision. (3)

2. At time $t = 0$ a ball is projected vertically upwards from a point O and rises to a maximum height of 40 m above O . The ball is modelled as a particle moving freely under gravity.

(a) Show that the speed of projection is 28 m s^{-1} . (3)

(b) Find the times, in seconds, when the ball is 33.6 m above O . (5)

3.

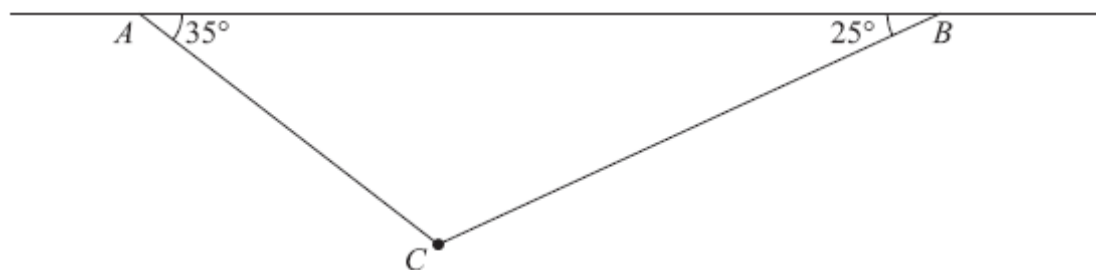


Figure 1

A particle of weight 8 N is attached at C to the ends of two light inextensible strings AC and BC . The other ends, A and B , are attached to a fixed horizontal ceiling. The particle hangs at rest in equilibrium, with the strings in a vertical plane. The string AC is inclined at 35° to the horizontal and the string BC is inclined at 25° to the horizontal, as shown in Figure 1.

Find

- (i) the tension in the string AC ,
- (ii) the tension in the string BC . (8)
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4. A particle P of mass 2 kg is attached to one end of a light string, the other end of which is attached to a fixed point O . The particle is held in equilibrium, with OP at 30° to the downward vertical, by a force of magnitude F newtons. The force acts in the same vertical plane as the string and acts at an angle of 30° to the horizontal, as shown in Figure 3.

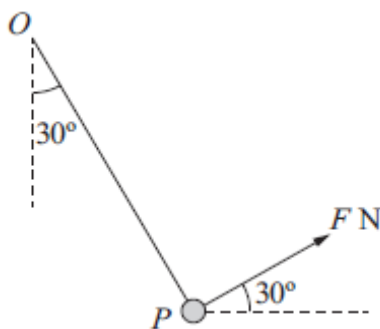


Figure 3

Find

- (i) the value of F ,
- (ii) the tension in the string.

(8)

5.

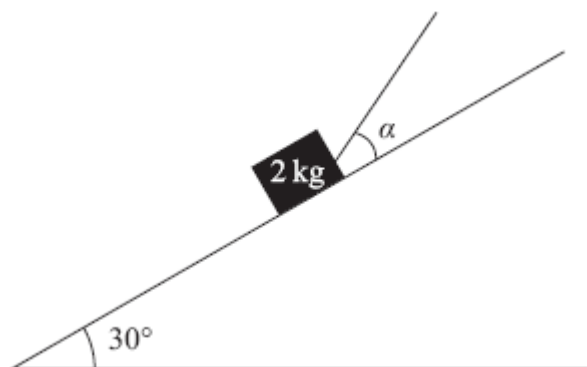


Figure 1

A box of mass 2 kg is held in equilibrium on a fixed rough inclined plane by a rope. The rope lies in a vertical plane containing a line of greatest slope of the inclined plane. The rope is inclined to the plane at an angle α , where $\tan \alpha = \frac{3}{4}$, and the plane is at an angle of 30° to the horizontal, as shown in Figure 1. The coefficient of friction between the box and the inclined plane is $\frac{1}{3}$ and the box is on the point of slipping up the plane. By modelling the box as a particle and the rope as a light inextensible string, find the tension in the rope.

(8)

6. A car is moving along a straight horizontal road. The speed of the car as it passes the point A is 25 m s^{-1} and the car maintains this speed for 30 s . The car then decelerates uniformly to a speed of 10 m s^{-1} . The speed of 10 m s^{-1} is then maintained until the car passes the point B . The time taken to travel from A to B is 90 s and $AB = 1410 \text{ m}$.

(a) Sketch a speed-time graph to show the motion of the car from A to B .

(2)

(b) Calculate the deceleration of the car as it decelerates from 25 m s^{-1} to 10 m s^{-1} .

(7)

7.

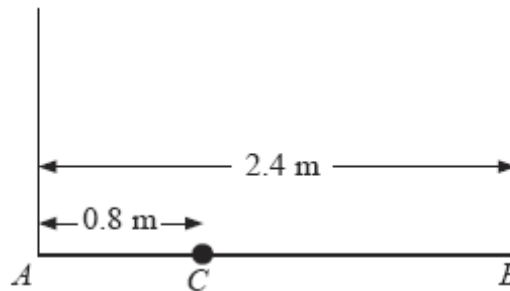


Figure 2

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 $AC = 0.8 \text{ m}$. 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 2. 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)

8.

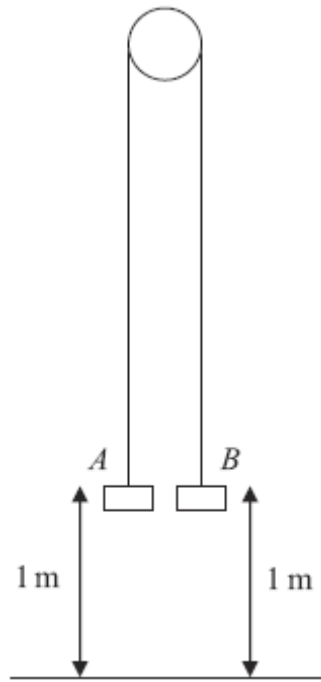


Figure 3

Two particles A and B have mass 0.4 kg and 0.3 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed above a horizontal floor. Both particles are held, with the string taut, at a height of 1 m above the floor, as shown in Figure 3. The particles are released from rest and in the subsequent motion B does not reach the pulley.

(a) Find the tension in the string immediately after the particles are released. **(6)**

(b) Find the acceleration of A immediately after the particles are released. **(2)**

When the particles have been moving for 0.5 s , the string breaks.

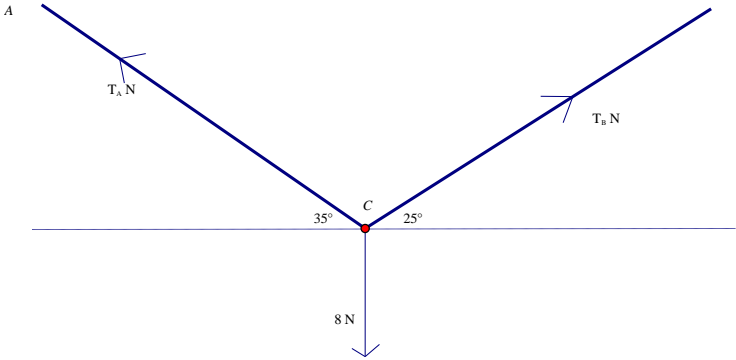
(c) Find the further time that elapses until B hits the floor. **(9)**

TOTAL FOR PAPER: 75 MARKS

END

Question Number	Scheme	Marks
1. (a)	$4m.2u - m.5u = -4m.\frac{1}{2}u + mv$ $3mu = -2mu + mv$ $v = 5u, \text{opposite direction}$	M1 A1 A1, A1 cs (4)
(b)	$I = 4m(\frac{1}{2}u - -2u) \quad \text{OR} \quad I = m(5u - -5u)$ $= 10mu \quad \quad \quad = 10mu$	M1 A1 A1 (3) 7

Question Number	Scheme	Marks
2. (a)	$0^2 = u^2 - 2 \times 9.8 \times 40$ $u = 28 \text{ m s}^{-1} \quad ** \text{ GIVEN ANSWER}$	M1 A1 A1 (3)
(b)	$33.6 = 28t - \frac{1}{2}9.8t^2$ $4.9t^2 - 28t + 33.6 = 0$ $t = \frac{28 \pm \sqrt{28^2 - 4 \times 4.9 \times 33.6}}{9.8}$ $= 4 \text{ s or } (1.7 \text{ s or } 1.71 \text{ s})$	M1 A1 M1 A1 A1 (5) 8

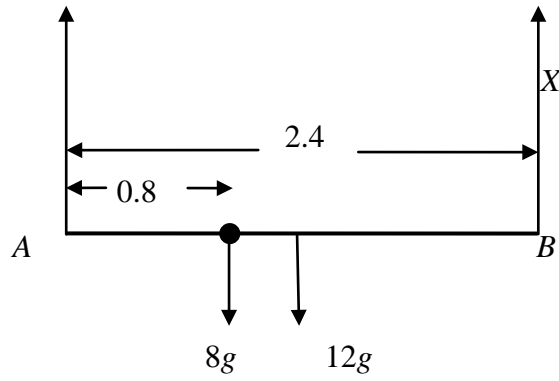
<p>3.</p>	 <p>Resolve horizontally: $T_A \cos 35^\circ = T_B \cos 25^\circ$ Resolve vertically: $T_A \sin 35^\circ + T_B \sin 25^\circ = 8$ Equation in one unknown: $T_B \frac{\cos 25^\circ}{\cos 35^\circ} \sin 35^\circ + T_B \sin 25^\circ = 8$ or $T_A \sin 35^\circ + T_A \frac{\cos 35^\circ}{\cos 25^\circ} \sin 25^\circ = 8$</p> <p>$T_A = 8.4, 8.37, 8.372$ (N) or better $T_B = 7.6, 7.57, 7.567$ (N) or better</p>	<p>M1A1 M1A1 DM1A1</p> <p>A1 A1</p> <p style="text-align: right;">(8) [8]</p>
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Question Number	Scheme	Marks
<p>4.</p>	<p>(\uparrow), $T \cos 30 + F \cos 60 = 2g$ (\rightarrow), $T \cos 60 - F \cos 30 = 0$ $F = g = 9.8$ $T = \sqrt{3}g = 17$ or 17.0</p> <p>OR:</p> <p>(\nearrow), $F = 2g \cos 60$ (\nwarrow), $T = 2g \cos 30$ $F = g = 9.8$ $T = \sqrt{3}g = 17$ or 17.0</p>	<p>M1 A1 M1 A1</p> <p>M1 A1 M1 A1 8</p> <p>M1 A1 M1 A1</p> <p>M1 A1 M1 A1 8</p>

5.	$T \cos \alpha - F = 2g \cos 60^\circ$ $T \sin \alpha + R = 2g \cos 30^\circ$ $F = \frac{1}{3}R$ eliminating F and R $T = g(1 + \frac{1}{\sqrt{3}})$, 1.6g (or better), 15.5, 15 (N)	M1 A1 M1 A1 B1 DM1 DM1 A1 (8) [8]
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6.	<p>(a)</p> <p style="text-align: center;"> O 30 90 t </p>	<p style="text-align: right;">shape</p> <p style="text-align: center;">25, 10, 30, 90</p>	<p style="text-align: right;">B1</p> <p style="text-align: right;">B1 (2)</p>
(b)	<p>(b) $30 \times 25 + \frac{1}{2}(25 + 10)t + 10(60 - t) = 1410$</p> <p style="text-align: center;">$7.5t = 60$</p> <p style="text-align: center;">$t = 8 \text{ (s)}$</p> <p style="text-align: center;">$a = \frac{25 - 10}{8} = 1.875 \text{ (ms}^{-2}\text{)}$ $1\frac{7}{8}$</p>	<p style="text-align: right;">M1 <u>A1</u> A1</p> <p style="text-align: right;">M1 A1</p> <p style="text-align: right;">M1 A1 (7)</p> <p style="text-align: right;">(9 marks)</p>	

7. (a)



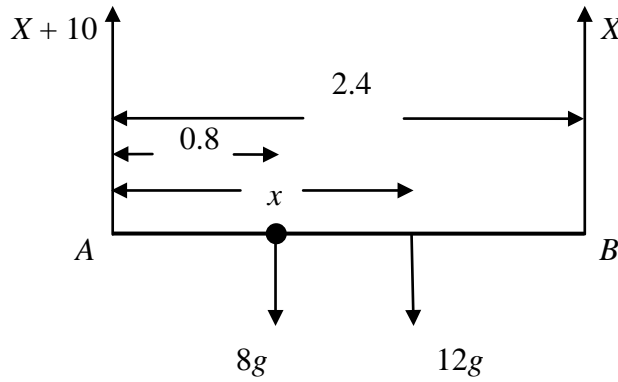
$$M(A) \quad 8g \times 0.8 + 12g \times 1.2 = X \times 2.4$$

$$X \approx 85 \text{ (N)} \quad \text{accept } 84.9, \frac{26g}{3}$$

M1 A1

DM1 A1 (4)

(b)



$$R(\uparrow) \quad (X + 10) + X = 8g + 12g$$

$$(X = 93)$$

$$M(A) \quad 8g \times 0.8 + 12g \times x = X \times 2.4$$

$$x = 1.4 \text{ (m)} \quad \text{accept } 1.36$$

M1 B1 A1

M1 A1

A1 (6)

(10 marks)

Q8	<p>(a) $(\downarrow)0.4g - T = 0.4a$ $(\uparrow)T - 0.3g = 0.3a$ solving for T $T = 3.36$ or 3.4 or $12g/35$ (N)</p> <p>(b) $0.4g - 0.3g = 0.7a$ $a = 1.4 \text{ m s}^{-2}, g/7$</p> <p>(c) $(\uparrow)v = u + at$ $v = 0.5 \times 1.4$ $= 0.7$</p> $(\uparrow)s = ut + \frac{1}{2}at^2$ $s = 0.5 \times 1.4 \times 0.5^2$ $= 0.175$ $(\downarrow)s = ut + \frac{1}{2}at^2$ $1.175 = -0.7t + 4.9t^2$ $4.9t^2 - 0.7t - 1.175 = 0$ $t = \frac{0.7 \pm \sqrt{0.7^2 + 19.6 \times 1.175}}{9.8}$ $= 0.5663 \dots$ <p>Ans 0.57 or 0.566 s</p>	M1 A1 M1 A1 DM1 A1 (6)
		DM1 A1 (2)
		M1 A1 ft on a
		M1 A1 ft on a
		DM1 A1 ft
		DM1 A1 cao
		A1 cao (9)
		[17]

Examiner reports

Question 1

The vast majority of candidates wrote down an appropriate ‘conservation of linear momentum’ equation for part (a). There were occasional sign errors and the few who tried to equate impulses often did not take account of directions. Most reached the required positive value for speed ($5u$) but, those who took the opposite direction as positive, sometimes left their answer as $-5u$ and lost a mark. It was important that the subsequent direction of motion of Q was described in the context of the problem (such as ‘direction reversed’ or ‘opposite direction’) and not relative to the candidate’s diagram (such as ‘to the right’ or by drawing an arrow). In the second part almost all quoted and used a correct impulse formula, applying it to either the motion of P or Q . The relevant velocities for P were given in the question, so there were no follow through accuracy marks for those who chose to use the impulse on Q with a wrong value from part (a). Sometimes direction was not properly accounted for leading to a sign error. Since the magnitude of the impulse was asked for, the positive value ‘ $10mu$ ’ was required for the final mark. Following correct working, some candidates wrongly stated the magnitude as ‘10’. Nevertheless, there were many entirely correct solutions seen.

Question 2

Part (a) was usually well-answered with most using $v^2 = u^2 + 2as$ but a surprising number of candidates put $u = 0$ and tried to find v , instead of the other way round. In the second part, those who wrote down a quadratic equation in t usually obtained a correct equation. Solving the equation proved more problematical, however, with some using an incorrect quadratic formula ($b^2 + 4ac$ was seen a number of times) while others appeared simply to be in alien territory. Some of the better candidates obtained a quadratic with integer coefficients, factorised successfully but then lost the final A1 for an answer of $\frac{12}{7}$.

The other popular choice was to find the velocity (± 11.2) at a height of 33.6 m and then go on to find the times, but it was very rare for *two* times to emerge, with almost all just using +11.2.

Question 3

This question was usually done very well with the vast majority resolving horizontally and vertically. Some candidates lost one or both of the final A marks due to rounding errors while others made an error in solving their simultaneous equations. A very small number of candidates used the Sine Rule on a triangle of forces, a few resolved along the strings and one or two resolved perpendicular to the strings. Those that assumed that the two tensions were equal lost most of the marks.

Question 4

The vertical and horizontal resolution option was by far the most popular method of solution but some candidates were unable to solve the resulting simultaneous equations. The alternative method, used by more astute candidates, produced a considerable number of very succinct ‘two lined’ solutions, gaining them seven quick marks. However, after such good solutions a surprising number lost the last accuracy mark. Solutions using a triangle of forces or Lami’s Theorem were not uncommon. A significant minority of candidates added a force R vertically which led to a great deal of confusion.

Question 5

The vast majority of candidates recognised that this equilibrium question required the resolution of forces in two directions. These were almost invariably (and sensibly) chosen to be parallel and perpendicular to the inclined plane. Candidates who used any other directions tended to miss out at least one force component and so make no valid progress. The question involved two distinct angles (the angle of inclination of the slope and the angle that the rope makes with the plane); in some responses there was evidence of confusion between these. In the perpendicular direction, some equated the normal reaction to the weight component, omitting the component of tension and thereby over-simplifying the problem. Nearly all used $F = \frac{1}{3}R$ appropriately in trying to eliminate F and then R from their two equations and many handled the terms and substitutions systematically, reaching a correct value for the tension. A better use of brackets would have helped some candidates who struggled to simplify the working involved. If $g = 9.8$ had been substituted, then two or three significant figures were required for the final answer, although an accurate answer in terms of g was also acceptable. Many fully correct solutions were seen.

Question 6

The speed-time graph in part (a) was well drawn with sufficient detail although a few candidates went beyond 90 on the t -axis. In the second part most tried to equate the area under their graph to 1410 but there were occasional errors and inconsistent use of the unknown time within the equation. Some found the area of the triangle to be 60 (correctly) but then used this as a distance in a constant acceleration formula to find the deceleration. The final two marks required the use of an appropriate value of t (i.e. not 38) and this was usually achieved although some, using the correct time value of 8, lost a mark by giving the deceleration as a negative value. More inexplicably, a few calculated the hypotenuse of a right-angled triangle rather than the gradient. Those who tried to use constant acceleration formulae for more than one stage of the motion at a time received no credit; such attempts were only very rarely seen.

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

In parts (a) and (b), most were able to make a reasonable attempt at two equations of motion, but there were errors in signs and solutions. This was not helped by the fact that T was asked for first rather than a and some candidates lost marks due to trying to solve for T first rather than the easier route of solving for a . A few attempted the whole system equation and these solutions were in general less successful than those who used two separate equations to start with. In the last part, too many candidates were unable to visualise the situation clearly and then deal with it in a methodical fashion. If they failed to find both the velocity of A on impact with the ground and the distance that it had travelled they were unable to progress any further. Only the more able students managed correct solutions. Of those that managed to progress in

part (c), there were sign errors which caused problems. Many chose to split the motion of B into two parts and these were usually quite successful provided that the extra distance travelled by B in the upward direction was taken into account.

Statistics for M1 Practice Paper Silver Level S2

Original paper	Qu	Mean score	Max score	Mean %	Mean score for students achieving grade:						
					ALL	A	B	C	D	E	U
1301	1	5.17	7	74	5.17	6.06	5.26	4.76	4.25	3.74	2.49
1106	2	5.50	8	69	5.50	6.98	6.00	5.19	4.36	3.56	2.05
1306R	3	5.74	8	72	5.74	7.12	5.80	4.67	2.91	3.37	1.56
1301	4	5.71	8	72	5.71	7.01	5.85	4.78	4.02	3.40	2.24
1306	5	5.83	8	73	5.83	7.24	6.66	6.08	5.24	3.95	1.90
0806	6	6.41	9	71	6.41	8.10	7.00	6.15	5.07	4.13	2.75
0806	7	5.94	10	59	5.94	8.61	6.73	5.26	3.69	2.48	1.06
1006	8	8.27	17	49	8.27	12.53	9.03	6.61	4.41	2.69	0.97
		48.57	75	65	48.57	63.65	52.33	43.50	33.95	27.32	15.02