

**6677/01**

# **Edexcel GCE**

## **Mechanics M1**

### **Silver Level S4**

**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**

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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**

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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**

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You must ensure that your answers to parts of questions are clearly labelled.

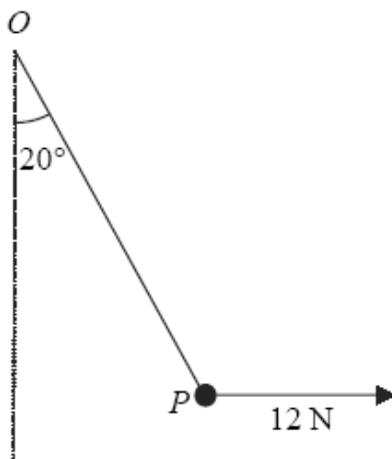
You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

#### **Suggested grade boundaries for this paper:**

<b>A*</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>
<b>67</b>	<b>59</b>	<b>51</b>	<b>43</b>	<b>33</b>	<b>26</b>

1.

Figure 1



A particle  $P$  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  $12\text{ N}$  is applied to  $P$ . The particle  $P$  is in equilibrium with the string taut and  $OP$  making an angle of  $20^\circ$  with the downward vertical, as shown in Figure 1.

Find

(a) the tension in the string, (3)

(b) the weight of  $P$ . (4)

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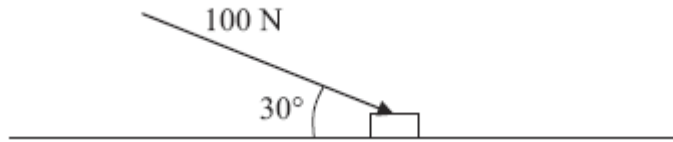
2. At time  $t = 0$ , a particle is projected vertically upwards with speed  $u\text{ m s}^{-1}$  from a point  $10\text{ m}$  above the ground. At time  $T$  seconds, the particle hits the ground with speed  $17.5\text{ m s}^{-1}$ . Find

(a) the value of  $u$ , (3)

(b) the value of  $T$ . (4)

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3.



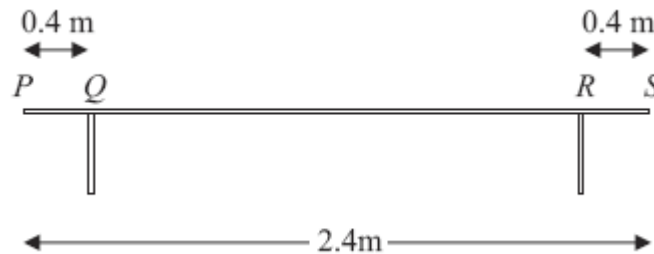
**Figure 1**

A small box is pushed along a floor. The floor is modelled as a rough horizontal plane and the box is modelled as a particle. The coefficient of friction between the box and the floor is  $\frac{1}{2}$ . The box is pushed by a force of magnitude 100 N which acts at an angle of  $30^\circ$  with the floor, as shown in Figure 1.

Given that the box moves with constant speed, find the mass of the box.

(7)

4.



**Figure 1**

A bench consists of a plank which is resting in a horizontal position on two thin vertical legs. The plank is modelled as a uniform rod  $PS$  of length 2.4 m and mass 20 kg. The legs at  $Q$  and  $R$  are 0.4 m from each end of the plank, as shown in Figure 1.

Two pupils, Arthur and Beatrice, sit on the plank. Arthur has mass 60 kg and sits at the middle of the plank and Beatrice has mass 40 kg and sits at the end  $P$ . The plank remains horizontal and in equilibrium. By modelling the pupils as particles, find

(a) the magnitude of the normal reaction between the plank and the leg at  $Q$  and the magnitude of the normal reaction between the plank and the leg at  $R$ .

(7)

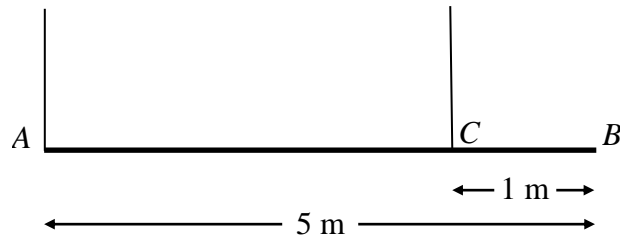
Beatrice stays sitting at  $P$  but Arthur now moves and sits on the plank at the point  $X$ . Given that the plank remains horizontal and in equilibrium, and that the magnitude of the normal reaction between the plank and the leg at  $Q$  is now twice the magnitude of the normal reaction between the plank and the leg at  $R$ ,

(b) find the distance  $QX$ .

(6)

5.

Figure 2



A beam  $AB$  has mass 12 kg and length 5 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. One rope is attached to  $A$ , the other to the point  $C$  on the beam, where  $BC = 1$  m, as shown in Figure 2. The beam is modelled as a uniform rod, and the ropes as light strings.

(a) Find

- (i) the tension in the rope at  $C$ ,
- (ii) the tension in the rope at  $A$ .

(5)

A small load of mass 16 kg is attached to the beam at a point which is  $y$  metres from  $A$ . The load is modelled as a particle. Given that the beam remains in equilibrium in a horizontal position,

(b) find, in terms of  $y$ , an expression for the tension in the rope at  $C$ .

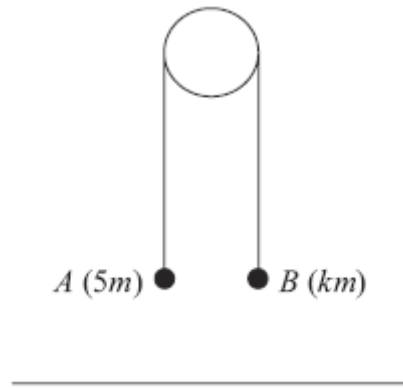
(3)

The rope at  $C$  will break if its tension exceeds 98 N. The rope at  $A$  cannot break.

(c) Find the range of possible positions on the beam where the load can be attached without the rope at  $C$  breaking.

(3)

6.



**Figure 4**

Two particles  $A$  and  $B$  have masses  $5m$  and  $km$  respectively, where  $k < 5$ . The particles 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, the hanging parts of the string vertical and with  $A$  and  $B$  at the same height above a horizontal plane, as shown in Figure 4. The system is released from rest. After release,  $A$  descends with acceleration  $\frac{1}{4}g$ .

(a) Show that the tension in the string as  $A$  descends is  $\frac{15}{4}mg$ . (3)

(b) Find the value of  $k$ . (3)

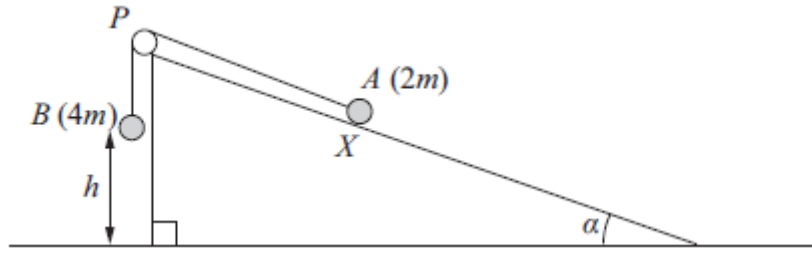
(c) State how you have used the information that the pulley is smooth. (1)

After descending for 1.2 s, the particle  $A$  reaches the plane. It is immediately brought to rest by the impact with the plane. The initial distance between  $B$  and the pulley is such that, in the subsequent motion,  $B$  does not reach the pulley.

(d) Find the greatest height reached by  $B$  above the plane. (7)

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7.



**Figure 5**

Figure 5 shows two particles  $A$  and  $B$ , of mass  $2m$  and  $4m$  respectively, connected by a light inextensible string. Initially  $A$  is held at rest on a rough inclined plane which is fixed to horizontal ground. The plane is inclined to the horizontal at an angle  $\alpha$ , where  $\tan \alpha = \frac{3}{4}$ . The coefficient of friction between  $A$  and the plane is  $\frac{1}{4}$ . The string passes over a small smooth pulley  $P$  which is fixed at the top of the plane. The part of the string from  $A$  to  $P$  is parallel to a line of greatest slope of the plane and  $B$  hangs vertically below  $P$ . The system is released from rest with the string taut, with  $A$  at the point  $X$  and with  $B$  at a height  $h$  above the ground.

For the motion until  $B$  hits the ground,

(a) give a reason why the magnitudes of the accelerations of the two particles are the same, (1)

(b) write down an equation of motion for each particle, (4)

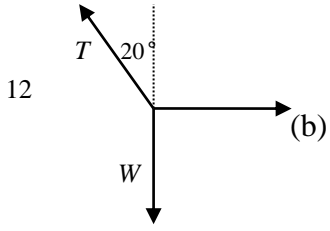
(c) find the acceleration of each particle. (5)

Particle  $B$  does not rebound when it hits the ground and  $A$  continues moving up the plane towards  $P$ . Given that  $A$  comes to rest at the point  $Y$ , without reaching  $P$ ,

(d) find the distance  $XY$  in terms of  $h$ . (6)

**TOTAL FOR PAPER: 75 MARKS**

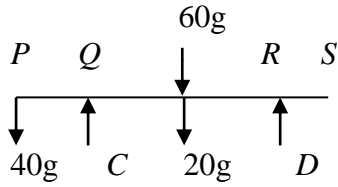
**END**

Question Number	Scheme	Marks
1.	<p>(a) <math>\rightarrow T \sin 20^\circ = 12</math>  <math>T \approx 35.1 \text{ (N)}</math> awrt 35</p>  <p>(b) <math>\uparrow W = T \cos 20^\circ</math>  <math>\approx 33.0 \text{ (N)}</math> awrt 33</p>	<p>M1 A1  A1 (3)</p> <p>M1 A1  DM1 A1 (4)  [7]</p>

2.	<p>(a) <math>v^2 = u^2 + 2as \Rightarrow 17.5^2 = u^2 + 2 \times 9.8 \times 10</math>  Leading to <math>u = 10.5</math></p> <p>(b) <math>v = u + at \Rightarrow 17.5 = -10.5 + 9.8T</math>  <math>T = 2\frac{6}{7} \text{ (s)}</math></p>	<p>M1 A1  A1 (3)  M1 A1 ft.  M1 A1 (4)  (7 marks)</p>
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Q3	<p>(<math>\rightarrow</math>) <math>100 \cos 30 = F</math>  <math>F = 0.5 R</math> seen</p> <p>(<math>\downarrow</math>) <math>mg + 100 \cos 60 = R</math>  <math>m = 13 \text{ kg}</math> or <math>12.6 \text{ kg}</math></p>	<p>M1 A1  A1 (B1)</p> <p>M1 A1  DM1 A1  [7]</p>
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4 (a)



$$C + D = 120g$$

$$M(Q), 80g \cdot 0.8 - 40g \cdot 0.4 = D \cdot 1.6$$

solving

$$C = 90g; D = 30g$$

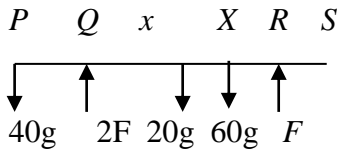
M1 A1  
M1 A1

M1  
A1 A1

(7

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(b)



$$2F + F = 40g + 20g + 60g$$

$$M(Q), 60gx + 20g \cdot 0.8 = 40g \cdot 0.4 + F \cdot 1.6$$

solving

$$QX = x = \frac{16}{15} m = 1.07m$$

M1 A1

M1 A1  
M1

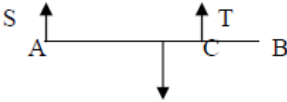
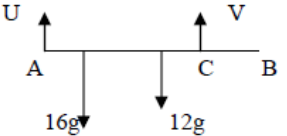
A1

(6

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[13]



Question Number	Scheme	Marks
5.(a)	 $M(A): T \times 4 = 12g \times 2.5$ $T = \underline{7.5g \text{ or } 73.5 \text{ N}}$ $R(\uparrow) S + T = 12g$ $\Rightarrow S = \underline{4.5g \text{ or } 44.1 \text{ N}}$	M1 A1 A1 M1 A1 (5)
(b)	 $M(A) V \times 4 = 16g \times y + 12g \times 2.5$ $V = \underline{4gy + 7.5g \text{ or } 39.2y + 73.5 \text{ N}}$	M1 A1 A1 (3)
(c)	$V \leq 98 \Rightarrow 39.2y + 73.5 \leq 98$ $\Rightarrow y \leq 0.625 = 5/8$ <p>Hence "load must be no more than 5/8 m from A" (o.e.)</p>	M1 DM1 A1 (3)
		<b>11</b>

Question Number	Scheme	Marks
Q6.	<p>(a) N2L A: <math>5mg - T = 5m \times \frac{1}{4}g</math></p> $T = \frac{15}{4}mg *$ <p style="text-align: right;">cs0</p>	M1 A1 A1 (3)
	<p>(b) N2L B: <math>T - kmg = km \times \frac{1}{4}g</math></p> $k = 3$	M1 A1 A1 (3)
	<p>(c) The tensions in the two parts of the string are the same</p>	B1 (1)
	<p>(d) Distance of A above ground <math>s_1 = \frac{1}{2} \times \frac{1}{4}g \times 1.2^2 = 0.18g (\approx 1.764)</math></p> <p>Speed on reaching ground <math>v = \frac{1}{4}g \times 1.2 = 0.3g (\approx 2.94)</math></p>	M1 A1 M1 A1
	<p>For B under gravity <math>(0.3g)^2 = 2gs_2 \Rightarrow s_2 = \frac{(0.3)^2}{2}g (\approx 0.441)</math></p> $S = 2s_1 + s_2 = 3.969 \approx 4.0 \text{ (m)}$	M1 A1 A1 (7)
		<b>[14]</b>

7. (a)	Inextensible string	B1 (1)
(b)	$4mg - T = 4ma$ $T - 2mg \sin \alpha - F = 2ma$ $F = 0.25R$	M1A1 M1A1 (4) B1 B1
(c)	$R = 2mg \cos \alpha$ $\cos \alpha = 0.8 \text{ or } \sin \alpha = 0.6$ <p>Eliminating <math>R, F</math> and <math>T</math></p> $a = 0.4g = 3.92$	B1 M1 A1 (5)
(d)	$v^2 = 2 \times 0.4gh$ $-2mg \sin \alpha - F = 2ma'$ $a' = -0.8g$ $0^2 = 0.8gh - 2 \times 0.8g \times s$ $s = 0.5h$ $XY = 0.5h + h = 1.5h$	M1 M1 A1 M1 A1 A1  (6) <b>16</b>

## Examiner reports

### Question 1

This was a straightforward starter question and a majority of candidates got off to a good start. A few thought that  $20/80$  were complementary angles whilst some did not check that their calculator was in degree mode.

#### *Part (a)*

Most were able to resolve correctly (with the occasional inevitable confusion between sin and cos) although some attempted to resolve parallel to the string, giving  $T = W\cos 20 + 12\sin 70$ , but omitted one of the terms, thus scoring zero.

#### *Part (b)*

Even if scoring zero in part (a), most candidates were able to gain 3 marks for this part. It is disturbing to find that a significant number of candidates for a Mechanics paper do not know the difference between mass and weight. A few candidates used the triangle of forces but sometimes slipped up by failing to take the essential step of drawing a separate triangle of forces diagram. Increasingly rarely seen, a few candidates successfully used Lami's theorem.

### Question 2

There were various approaches that could be applied successfully to answer this question. Those who fully understood the implications of projecting from above ground level could achieve full marks by the most direct method although sign errors were not uncommon. Another popular approach was to split the motion into two stages (to and from the highest point) in both part (a) to find the initial velocity, and in part (b) to find the whole time. Although this required more working, there tended to be fewer sign errors. Premature approximation occasionally led to inaccuracy in the final answer. The weakest candidates sometimes only considered motion to or from the highest point. It should be noted that the rubric requires  $g = 9.8$  to be used and not 9.81, which was penalised.

### Question 3

Many candidates scored well on this question. Most resolved in the horizontal direction correctly, with the occasional introduction of an acceleration term at first. In most cases this was equated to zero and most candidates were able to score the method marks at least. The mark for use of limiting friction was obtained by most. For the vertical resolution, the most common errors were either for mistakes in sign or else to state that  $R = mg$ , omitting the component of the 100 N force. Very few candidates solved for the weight rather than the mass. Accuracy errors were common, with 12.57 being a common, too accurate, answer.

### Question 4

Part (a) was well answered with the majority of candidates realising that they had to take moments. A common and costly error was to omit the distance when taking the moment of one or both of the reaction forces. Some candidates took moments twice, usually about  $Q$  then about  $R$  but these tended to be less successful than those who took moments and resolved vertically. A few students missed off  $g$ 's from their weight terms. In the second part, again the most productive method was to resolve vertically and use one moments equation. Those who opted to take moments twice had more algebraic manipulation to contend with, which at times was a problem. Poor diagrams often resulted in finding and using wrong distances.

## Question 5

Apart from the minority of candidates who, in their moments equation, failed to multiply the tension by a length (dimensionally incorrect  $\Rightarrow$  no marks) or those who omitted  $g$ , part (a) was well-answered. In the second part a number of candidates failed to re-arrange their moments equation to give an expression for the tension and made  $y$  the subject instead. Most proceeded, in the final part, via an equation rather than an inequality and very few made the final verbal statement referring specifically to the positioning of the load rather than a defined 'y'.

## Question 6

Part (a) was reasonably well done by the majority of students, with good use of the printed answer to correct sign errors etc. but there was less success in the second part, with omission of  $m$  and/or  $g$  from some terms. The mark in part (c) was very rarely scored and candidates should be aware that if they give a 'list' of answers they will not be awarded the mark, even if the correct answer appears in their list. The final part was a good discriminator and led to Q6 being the worst answered question on the paper. Consideration of two stages to the motion was required, with two distinct accelerations. Many completely omitted the motion under gravity and found the distance moved by  $A$  and either gave that as their answer or else just doubled it.

## Question 7

The relevant modelling assumption that leads to the accelerations of both particles being the same is that the string is inextensible. If additional but not relevant reasons were stated in part (a), the mark for this was withheld. Not all candidates realised, in the second part, that 'equation of motion' refers to Newton's Second Law (' $F = ma$ '), and some attempts at constant acceleration equations, or just combining forces, were seen. However, often these candidates proceeded to produce the correct equations in part (c) in order to calculate the acceleration; they were awarded marks retrospectively. Occasionally the weight was omitted from the resolution parallel to the plane but generally the friction term (including the normal reaction) was handled correctly. Correct trigonometric ratios were mostly identified and used appropriately. Generally the motion of connected particles seemed well understood although numerical slips, including sign errors when solving the simultaneous equations, sometimes led to a wrong final value for the acceleration. The final part proved to be much more of a challenge. Some realised that it was necessary to calculate the speed (in terms of  $h$ ) when one of the particles hits the ground, but then made little further progress. Those who realised that a new acceleration was required by applying Newton's Second Law parallel to the plane, sometimes made a sign error or omitted the weight component. A significant minority did complete their solutions, but with numerical or algebraic errors which led to a wrong answer. Having obtained  $v^2 = 0.8gh$  many then went on to write  $v = 2.8h$  (or similar) producing an  $h^2$  in the final equation. Nevertheless, there were some clear, entirely correct solutions seen.

## Statistics for M1 Practice Paper Silver Level S4

Original paper	Qu	Mean score	Max score	Mean %	Mean score for students achieving grade:						
					ALL	A	B	C	D	E	U
0706	1	4.95	7	71	4.95	6.63	5.78	4.81	3.74	2.67	1.17
0806	2	4.31	7	62	4.31	5.83	4.54	3.73	3.23	2.73	1.67
1006	3	4.90	7	70	4.90	6.30	5.54	4.76	3.87	2.88	1.40
0901	4	8.88	13	68	8.88	11.42	9.15	7.27	5.09	3.31	1.07
0801	5	6.98	11	63	6.98	9.45	7.77	5.36	3.90	2.15	1.34
1001	6	7.47	14	53	7.47	10.15	7.55	5.47	3.48	2.18	0.88
1301	7	8.44	16	53	8.44	11.31	8.21	6.00	4.66	3.14	1.78
		<b>45.93</b>	<b>75</b>	<b>61</b>	<b>45.93</b>	<b>61.09</b>	<b>48.54</b>	<b>37.40</b>	<b>27.97</b>	<b>19.06</b>	<b>9.31</b>