

Paper Reference(s)

**6677/01****Edexcel GCE****Mechanics M1****Bronze Level B5****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:**

A*	A	B	C	D	E
72	64	57	48	37	30

**Bronze 5**

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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  $4 \text{ m s}^{-1}$  and the speed of  $C$  is  $2 \text{ m s}^{-1}$ . 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  $1 \text{ m s}^{-1}$  and the speed of  $C$  is  $3 \text{ m s}^{-1}$ .

Find

- (a) the value of  $m$ , (3)

- (b) the magnitude of the impulse received by  $C$ . (2)
- 

2. A car moves along a horizontal straight road, passing two points  $A$  and  $B$ . At  $A$  the speed of the car is  $15 \text{ m s}^{-1}$ . When the driver passes  $A$ , he sees a warning sign  $W$  ahead of him, 120 m away. He immediately applies the brakes and the car decelerates with uniform deceleration, reaching  $W$  with speed  $5 \text{ m s}^{-1}$ . At  $W$ , the driver sees that the road is clear. He then immediately accelerates the car with uniform acceleration for 16 s to reach a speed of  $V \text{ m s}^{-1}$  ( $V > 15$ ). He then maintains the car at a constant speed of  $V \text{ m s}^{-1}$ . Moving at this constant speed, the car passes  $B$  after a further 22 s.

- (a) Sketch, in the space below, a speed-time graph to illustrate the motion of the car as it moves from  $A$  to  $B$ . (3)

- (b) Find the time taken for the car to move from  $A$  to  $B$ . (3)

The distance from  $A$  to  $B$  is 1 km.

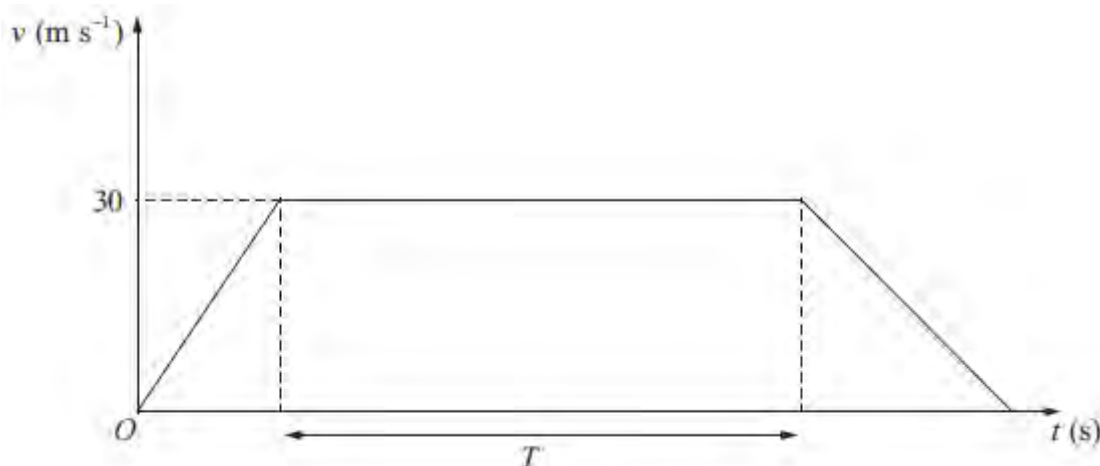
- (c) Find the value of  $V$ . (5)
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3. A lorry is moving along a straight horizontal road with constant acceleration. The lorry passes a point  $A$  with speed  $u \text{ m s}^{-1}$ , ( $u < 34$ ), and 10 seconds later passes a point  $B$  with speed  $34 \text{ m s}^{-1}$ . Given that  $AB = 240 \text{ m}$ , find

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

- (b) the time taken for the lorry to move from  $A$  to the mid-point of  $AB$ . (6)
-

4.

**Figure 4**

The velocity-time graph in Figure 4 represents the journey of a train  $P$  travelling along a straight horizontal track between two stations which are 1.5 km apart. The train  $P$  leaves the first station, accelerating uniformly from rest for 300 m until it reaches a speed of  $30 \text{ m s}^{-1}$ . The train then maintains this speed for  $T$  seconds before decelerating uniformly at  $1.25 \text{ m s}^{-2}$ , coming to rest at the next station.

(a) Find the acceleration of  $P$  during the first 300 m of its journey. (2)

(b) Find the value of  $T$ . (5)

A second train  $Q$  completes the same journey in the same total time. The train leaves the first station, accelerating uniformly from rest until it reaches a speed of  $V \text{ m s}^{-1}$  and then immediately decelerates uniformly until it comes to rest at the next station.

(c) Sketch on the diagram above, a velocity-time graph which represents the journey of train  $Q$ . (2)

(d) Find the value of  $V$ . (6)

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5. A ball is projected vertically upwards with a speed of  $14.7 \text{ m s}^{-1}$  from a point which is 49 m above horizontal ground. Modelling the ball as a particle moving freely under gravity, find

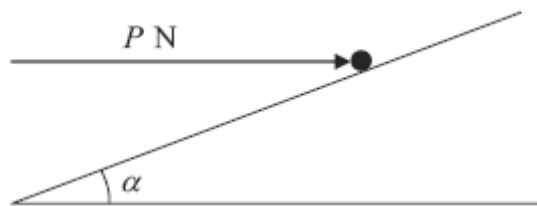
(a) the greatest height, above the ground, reached by the ball, (4)

(b) the speed with which the ball first strikes the ground, (3)

(c) the total time from when the ball is projected to when it first strikes the ground. (3)

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6.

**Figure 2**

A particle of mass  $0.4 \text{ kg}$  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  $\alpha$ , where  $\tan \alpha = \frac{3}{4}$ , as shown in Figure 2.

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

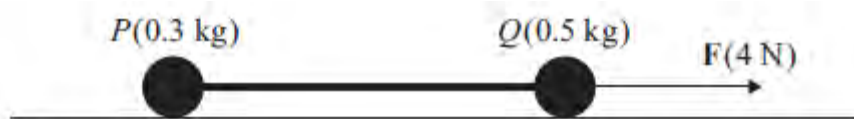
Given that the particle is on the point of sliding up the plane, find

(a) the magnitude of the normal reaction between the particle and the plane, (5)

(b) the value of  $P$ . (5)

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7.

**Figure 3**

Two particles  $P$  and  $Q$ , of mass  $0.3\text{ kg}$  and  $0.5\text{ kg}$  respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane.

At time  $t = 0$ , a constant force  $\mathbf{F}$  of magnitude  $4\text{ N}$  is applied to  $Q$  in the direction  $PQ$ , as shown in Figure 3. The system moves under the action of this force until  $t = 6\text{ s}$ . During the motion, the resistance to the motion of  $P$  has constant magnitude  $1\text{ N}$  and the resistance to the motion of  $Q$  has constant magnitude  $2\text{ N}$ .

Find

(a) the acceleration of the particles as the system moves under the action of  $\mathbf{F}$ , (3)

(b) the speed of the particles at  $t = 6\text{ s}$ , (2)

(c) the tension in the rod as the system moves under the action of  $\mathbf{F}$ . (3)

At  $t = 6\text{ s}$ ,  $\mathbf{F}$  is removed and the system decelerates to rest. The resistances to motion are unchanged. Find

(d) the distance moved by  $P$  as the system decelerates, (4)

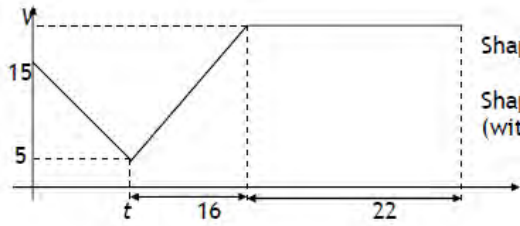
(e) the thrust in the rod as the system decelerates. (3)

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**TOTAL FOR PAPER: 75 MARKS**

**END**

Question Number	Scheme	Marks
1.		
(a)	Conservation of momentum: $4m \times 6 = m + 9$ $m = 5$	M1 A1 A1 (3)
(b)	Impulse = change in momentum $= 3 \times 3 - (3 \times -2) = 15$	M1 A1 (2) [5]

Question Number	Scheme	Marks
2(a)		B1 B1 B1 (3)
(b)	$\frac{1}{2}(15 + 5) \times t = 120$ $\Rightarrow t = 12 \rightarrow T = 12 + 16 + 22 = 50 \text{ s}$	M1 M1 A1 (3)
(c)	$120 + \frac{1}{2}(V + 5) \cdot 16 + 22V = 1000$ Solve: $30V = 840 \Rightarrow V = 28$	M1 B1 A1 DM1 A1 (5) 11

3. (a)	$240 = \frac{1}{2}(u + 34)10$ $u = 14$	M1 A1 A1 (3)
(b)	$34 = 14 + 10a \Rightarrow a = 2$ $120 = 14t + \frac{1}{2} \times 2 \times t^2$ $t^2 + 14t - 120 = 0$ Solving, $t = -20$ or $6$ $t = 6$  <b>OR</b> $34 = 14 + 10a \Rightarrow a = 2$ $v^2 = 14^2 + 2 \times 2 \times 120 \Rightarrow v = 26$ AND $26 = 14 + 2t$ $t = 6$	M1 A1 M1 A1    DM1 A1  M1 A1  M1 A1 DM1 A1 (6) [9]

4.	$30^2 = 2a \cdot 300$ $a = 1.5$	M1 A1 (2)
	$0^2 = 30^2 - 2 \times 1.25s \quad \text{OR} \quad 0 = 30 - 1.25t_2$ $s = 360 \quad t_2 = 24$ $300 + 30T + 360 = 1500 \quad \frac{(20 + T + 24 + T)}{2} \times 30 = 1500$ $T = 28 \quad T = 28$ <p>triangle, <i>drawn on the diagram</i>, with base coinciding with base of trapezium, top vertex above line <math>v = 30</math> and meeting trapezium at least once</p>	M1 A1 M1 A1 A1 (5)
	$V$ marked correctly	B1 DB1 (2)
	$30 = 1.5t_1 \Rightarrow t_1 = 20$ $30 = 1.25t_2 \Rightarrow t_2 = 24$ $\frac{1}{2}(20 + 28 + 24)V = 1500$ $V = \frac{750}{18} = 41.67$ $= \frac{125}{3} \text{ (oe) 0r 42 (or better)}$	M1 A1 A1 M1 A1 A1 (6)
		<b>15</b>

<p>Q5 (a)</p> <p>(b)</p> <p>(c)</p>	<p> <math>(\uparrow)v^2 = u^2 + 2as</math>  <math>0 = 14.7^2 - 2 \times 9.8 \times s</math>  <math>s = 11.025</math> (or 11 or 11.0 or 11.03) m            Height is 60 m or 60.0 m <b>ft</b> </p> <p> <math>(\downarrow)v^2 = u^2 + 2as</math>  <math>v^2 = (-14.7)^2 + 2 \times 9.8 \times 49</math>  <math>v = 34.3</math> or <math>34 \text{ m s}^{-1}</math> </p> <p> <math>(\downarrow)v = u + at</math>                      <b>OR</b>                      <math>(\downarrow)s = ut + \frac{1}{2}at^2</math>  <math>34.3 = -14.7 + 9.8t</math>                      <math>49 = -14.7t + 4.9t^2</math>  <math>t = 5</math>    <math>t = 5</math> </p>	<p>M1A1 A1 A1ft (4)</p> <p>M1 A1 A1 (3)</p> <p>M1 A1 A1 (3)</p> <p>[10]</p>
<p>Q6 (a)</p> <p>(b)</p>	<p> <math>F = \frac{1}{3}R</math>  <math>(\uparrow) R \cos \alpha - F \sin \alpha = 0.4g</math>  <math>R = \frac{2}{3}g = 6.53</math> or <math>6.5</math> </p> <p> <math>(\rightarrow)P - F \cos \alpha - R \sin \alpha = 0</math>  <math>P = \frac{26}{45}g = 5.66</math> or <math>5.7</math> </p>	<p>B1</p> <p>M1 A1 M1 A1 (5)</p> <p>M1 A2 M1 A1 (5)</p> <p>[10]</p>



Question Number	Scheme	Marks
7.	<div data-bbox="352 342 1190 499" style="text-align: center;"> </div> <p>(a) For system N2L <math>4 - 3 = 0.8a</math>  <math>a = 1.25 \text{ (m s}^{-2}\text{)}, 1.3</math></p> <p>(b) <math>v = u + at \Rightarrow v = 0 + 1.25 \times 6 = 7.5 \text{ (m s}^{-1}\text{)}</math></p> <p>(c) For P N2L <math>T - 1 = 0.3 \times 1.25</math> ft their <math>a</math>  <math>T = 1.375 \text{ (N)} 1.38, 1.4</math></p> <p><b>OR</b> For Q N2L <math>4 - 2 - T = 0.5 \times 1.25</math></p> <div data-bbox="352 969 1190 1126" style="text-align: center;"> </div> <p>(d) For system N2L <math>-3 = 0.8a \Rightarrow a = -3.75</math>  <math>v^2 = u^2 + 2as \Rightarrow 0^2 = 7.5^2 - 2 \times 3.75s</math>  <math>s = 7.5 \text{ (m)}</math></p> <p>(e) For P N2L <math>T' + 1 = 0.3 \times 3.75</math>  <math>T' = 0.125 \text{ (N)}, 0.13</math></p>	<p>M1 A1 A1 (3)</p> <p>M1 A1 (2)</p> <p>M1 A1ft A1 (3)</p> <p>M1 A1 M1 A1 (4)</p> <p>M1 A1 A1 (3)</p> <p>[15]</p>

## 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 the first part the majority were able to produce a reasonable speed-time graph – errors usually occurring due to the omission of time details; also a few had  $V < 15$  and some candidates included a section for the time before  $t = 0$ .

In part (b) most were able to calculate the time for the first part of the motion correctly but there were candidates who assumed that the area involved was a triangle.

### Question 3

This is an area of the syllabus in which most candidates feel comfortable and many achieved full marks on this question. There were, however, a number of instances of incorrect formulae being quoted, the most common being  $s = \frac{1}{2}(v - u)t$ .

In part (a) almost all found  $u = 14$ , some by first finding  $a = 2$ , thus securing a couple of bonus marks in part (b), although there were an unfortunate few who having found  $a = 2$  in part (a) worked it out again, using a different method, in part (b), got it wrong and then lost their bonus marks by using this wrong answer. The second part was mostly done by setting up and solving a three term quadratic and mostly this went well. A significant minority first found  $v = 26$  at the mid-point and then used it to obtain  $t = 6$ . This proved to be a comparatively risk-free path since it deprived candidates of the opportunity to use an incorrect quadratic formula or to make a sign error in evaluating the discriminant. Common errors included using  $v = 34$  at the halfway point and assuming that the average speed,  $24 \text{ m s}^{-1}$ , occurred at the mid-distance point rather than at the mid-time.

### Question 4

In part (a) the vast majority were able to obtain the acceleration, either directly or else by finding the time first. The easiest way of finding  $T$  in the second part was to find the distance 360 and then use  $30T = 840$ , but finding  $t = 24$  for the final stage was a common first step. In part (c), many lost two marks by not drawing the triangle onto the trapezium and those who redrew only drew a triangle, hence still losing both marks. It was rare to see a completely redrawn whole diagram. In addition, many failed to mark  $V$  on their diagram. In the final part there were many who got the first three marks by getting an overall time of 72. There were a good number of candidates who used the area of the whole triangle but it certainly wasn't obvious to all and, as a result, there were some more complicated but accurate solutions. Where errors occurred it often came from students wanting to apply *suvat* to the whole distance, or getting bogged down trying to use *suvat* with unknown values of  $V$  and  $t$ , while

others were successful in using an isosceles triangle. A few candidates producing correct working lost the final mark through recording 41.6.

### Question 5

This question was generally well done and often a useful source of marks for weaker candidates. Virtually all used a valid method to find the greatest height although not all added on the '49' to take account of the starting level. Those who did often failed to give their answer to an appropriate degree of precision (2 or 3 significant figures having used  $g = 9.8$ ). Part (b), which involved finding the velocity at ground level, was also largely successfully completed although there was occasional confusion about which figure for height to use. To find the time of flight in part (c), many candidates split the motion into up/down stages and were largely successful. Those who tried to use the whole motion sometimes made sign errors.

### Question 6

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.

### Question 7

As is usually the case with questions of this type, better candidates who understood the principles scored well and there were a significant number of fully correct answers. Better candidates benefited from appreciating that Newton's Law needed to be applied to either the whole system or to a single particle. The nature of these questions is that errors often involve missing or extra forces and this causes a significant loss of marks. The *suvat* parts were done quite well although a number of candidates tried to use the information about  $t$  or  $T$  from parts (b) and (c), in part (d) and this usually caused major difficulties.

The majority of candidates answered part (a) correctly, usually by considering the whole system, but sometimes by considering the particles separately and eliminating  $T$ . Candidates who considered just one particle, by omitting  $T$ , rarely achieved success in any subsequent part of the question (although they usually picked up the M1 in part (b)). The vast majority answered the second part correctly. In part (c) most candidates were able to produce an equation of motion for one of the particles and those who scored full marks in part (a), generally scored full marks in parts (b) and (c) also. There was a minority, however, who appeared to have no idea how to cope with the particles separately; these candidates might score highly in parts (a), (b), and even in part (d), but they seemed stumped when they couldn't use 0.8 as the relevant mass i.e. in parts (c) and (e). In part (d) a new acceleration was needed and many candidates calculated it correctly then used it appropriately to find the distance travelled. A variety of errors appeared here. Some candidates used the old acceleration, others used  $g$ , some used just one particle and left out the thrust while others kept the 4N force. Others didn't think they needed an acceleration because they used  $t = 6$  and

$s = \frac{t(u+v)}{2}$ . Part (e) caused the most difficulty and a number of candidates were put off by the unfamiliar concept of a thrust.

### Statistics for M1 Practice Paper Bronze Level B5

Original paper	Qu	Mean score	Max score	Mean %	Mean score for students achieving grade:						
					ALL	A	B	C	D	E	U
1101	1	4.38	5	88	4.38	4.75	4.45	4.12	3.73	3.40	2.17
0801	2	8.37	11	76	8.37	10.11	8.55	7.37	6.11	4.86	3.19
1306	3	7.40	9	82	7.40	8.63	8.16	7.55	6.83	5.89	3.82
1301	4	11.69	15	78	11.69	13.46	11.83	10.74	9.44	8.09	5.96
1006	5	7.53	10	75	7.53	9.01	8.21	7.50	6.62	5.62	3.34
1006	6	6.02	10	60	6.02	8.37	6.93	5.50	4.08	2.69	1.04
1206	7	9.27	15	62	9.27	12.88	10.31	8.26	6.19	4.29	2.06
		<b>54.66</b>	<b>75</b>	<b>73</b>	<b>54.66</b>	<b>67.21</b>	<b>58.44</b>	<b>51.04</b>	<b>43.00</b>	<b>34.84</b>	<b>21.58</b>