Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Bronze Level B4

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

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 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
73	65	58	48	37	30

1. A particle A of mass 2 kg is moving along a straight horizontal line with speed 12 m s^{-1}. Another particle B of mass m kg is moving along the same straight line, in the opposite direction to A, with speed 8 m s^{-1}. The particles collide. The direction of motion of A is unchanged by the collision. Immediately after the collision, A is moving with speed 3 m s^{-1} and B is moving with speed 4 m s^{-1}. Find

(*a*) the magnitude of the impulse exerted by B on A in the collision,

(2)

(*b*) the value of m.

(4)

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2. Two particles A and B, of mass 0.3 kg and m kg respectively, are moving in opposite directions along the same straight horizontal line so that the particles collide directly. Immediately before the collision, the speeds of A and B are 8 m s^{-1} and 4 m s^{-1} respectively. In the collision the direction of motion of each particle is reversed and, immediately after the collision, the speed of each particle is 2 m s^{-1}.

Find

(*a*) the magnitude of the impulse exerted by B on A in the collision,

(3)

(*b*) the value of m.

(4)

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3. A girl runs a 400 m race in a time of 84 s. In a model of this race, it is assumed that, starting from rest, she moves with constant acceleration for 4 s, reaching a speed of 5 m s^{-1}. She maintains this speed for 60 s and then moves with constant deceleration for 20 s, crossing the finishing line with a speed of V m s^{-1}.

(*a*) Sketch a speed-time graph for the motion of the girl during the whole race.

(2)

(*b*) Find the distance run by the girl in the first 64 s of the race.

(3)

(*c*) Find the value of V.

(5)

(*d*) Find the deceleration of the girl in the final 20 s of her race.

(2)

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4. A car is moving along a straight horizontal road. At time $t = 0$, the car passes a point A with speed 25 m s^{-1}. The car moves with constant speed 25 m s^{-1} until $t = 10$ s. The car then decelerates uniformly for 8 s. At time $t = 18$ s, the speed of the car is $V \text{ m s}^{-1}$ and this speed is maintained until the car reaches the point B at time $t = 30$ s.

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

(3)

Given that $AB = 526$ m, find

(*b*) the value of V,

(5)

(*c*) the deceleration of the car between $t = 10$ s and $t = 18$ s.

(3)

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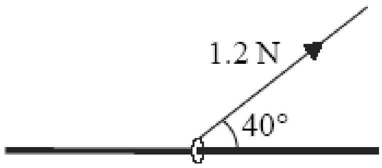
5. **Figure 3**



A small ring of mass 0.25 kg is threaded on a fixed rough horizontal rod. The ring is pulled upwards by a light string which makes an angle 40° with the horizontal, as shown in Figure 3. The string and the rod are in the same vertical plane. The tension in the string is 1.2 N and the coefficient of friction between the ring and the rod is μ. Given that the ring is in limiting equilibrium, find

(*a*) the normal reaction between the ring and the rod,

(4)

(*b*) the value of μ.

(6)

6.

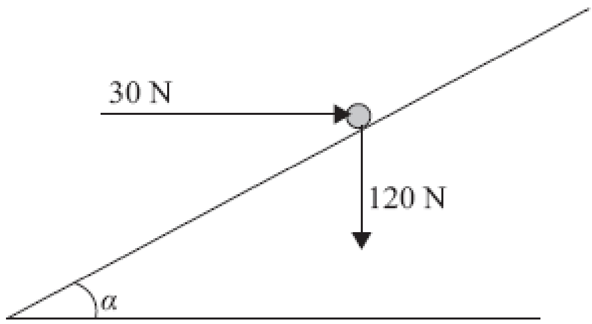


Figure 4

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)

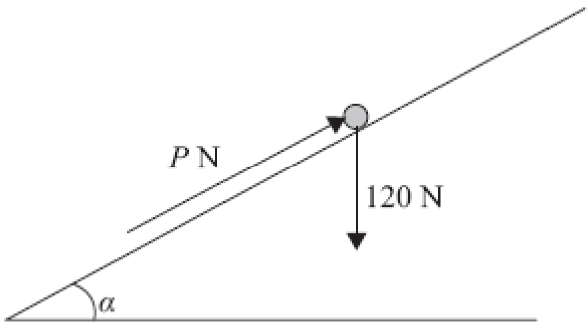


Figure 3

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)

7.

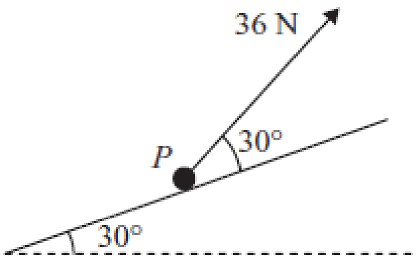


Figure 2

A particle P of mass 4 kg is moving up a fixed rough plane at a constant speed of 16 m s^{-1} under the action of a force of magnitude 36 N. The plane is inclined at 30° to the horizontal. The force acts in the vertical plane containing the line of greatest slope of the plane through P, and acts at 30° to the inclined plane, as shown in Figure 2. The coefficient of friction between P and the plane is μ. Find

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

(4)

(*b*) the value of μ.

(5)

The force of magnitude 36 N is removed.

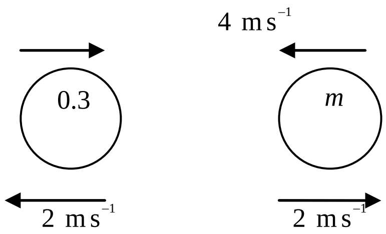
(*c*) Find the distance that P travels between the instant when the force is removed and the instant when it comes to rest.

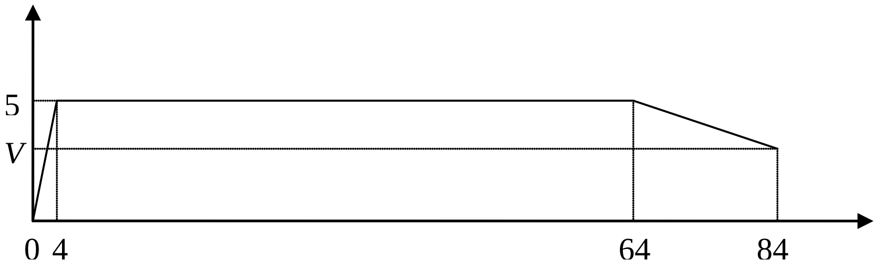
(5)

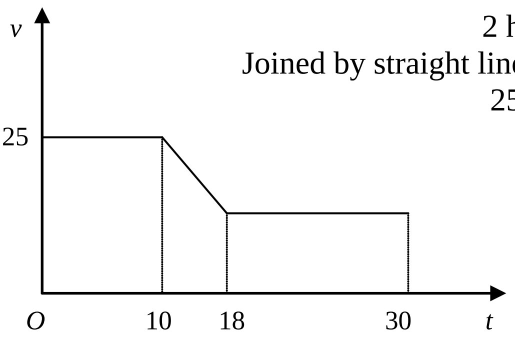
TOTAL FOR PAPER: 75 MARKS

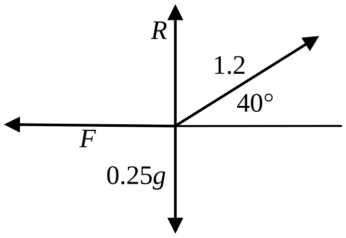
END

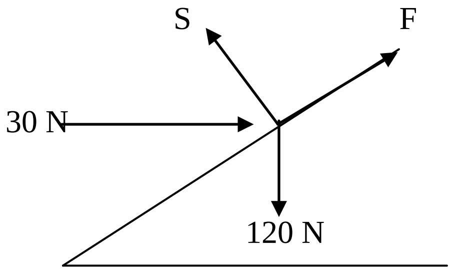
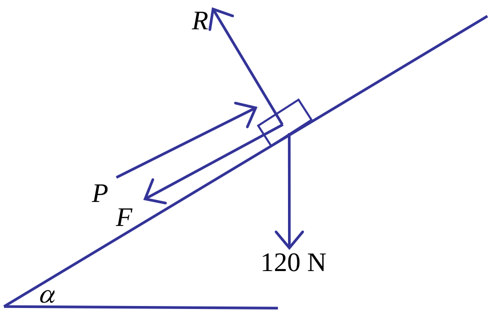
Question Number	Scheme	Marks
Q1.	(a) $I = 2\times 12 - 2\times 3 = 18\ (\text{N s})$	M1 A1 (2)
	(b) LM $2\times 12 - 8m = 2\times 3 + 4m$ Solving to $m = 1.5$	M1 A1 DM1 A1 (4) **[6]**
	Alternative to (b) $I = m\left(4-(-8)\right) = 18$ Solving to $m = 1.5$	 M1 A1 DM1 A1 (4)

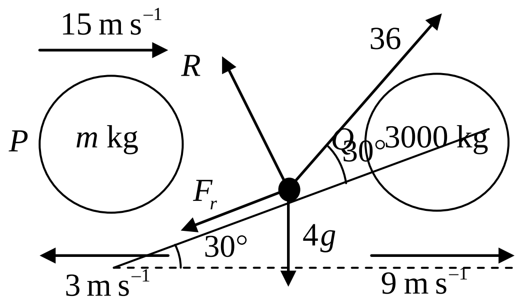
Question Number	Scheme	Marks
2.		
	(a) A: $I = 0.3(8+2)$ $= 3\ (\text{Ns})$	M1 A1 A1 **(3)**
	(b) LM $0.3\times 8 - 4m = 0.3\times(-2) + 2m$ $m = 0.5$	M1 A1 DM1 A1 **(4)** **[7]**
	Alternative to (b) B: $m(4+2) = 3$ $m = 0.5$	M1 A1 DM1 A1 **(4)**
	The two parts of this question may be done in either order.	

Question Number	Scheme	Marks
3. (a)		B1 shape B1 figs (2)
(b)	$(\frac{1}{2}\text{x}4\text{x}5) + 60 \text{ x } 5$ = 310	M1 A1 A1 (3)
(c)	$\frac{(5+V)}{2}$ x 20 = (400-310) $V = 4$	M1 A2 **ft** **DM**1 A1 (5)
(d)	$\frac{5-4}{20} = 0.05$ ms^{-2}	M1 A1 (2) **12**

Question Number	Scheme	Marks
4.	(a)  2 horizontal lines Joined by straight line sloping down 25, 10, 18, 30 oe	B1 B1 B1 **(3)**
	(b) $25\times10+\frac{1}{2}(25+V)\times8+12\times V=526$ Solving to $V=11$	M1 <u>A1</u> A1 DM1 A1 **(5)**
	(c) $"v=u+at" \Rightarrow 11=25-8a$ ft their V $a=1.75$ (m s^{-2})	M1 A1ft A1 **(3)** **[11]**

Question Number	Scheme		Marks
5.	(a) 		
	$\uparrow \quad \pm\ R + 1.2\sin 40° = 0.25g$		M1 A1
	Solving to $R = 1.7 \quad (\text{N})$	accept 1.68	DM1 A1 **(4)**
	(b) $\rightarrow \quad F = 1.2\cos 40° \quad (\approx 0.919)$		M1 A1
	Use of $F = \mu R$		B1
	$1.2\cos 40° = \mu R$	ft their R	DM1 A1ft
	$\mu \approx 0.55$	accept 0.548	A1 cao
			(6)
			[10]

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

Question Number	Scheme	Marks
7. (a)		
	$R + 36\sin 30° = 4g\cos 30°$	M1 A1
	$R \approx 15.9,\ 16$	M1 A1
		(4)
(b)	Use of $F_r = \mu R$	B1
	$36\cos 30° = F + 4g\sin 30°$	M1 A1
	$\mu = \dfrac{36\cos 30° - 4g\sin 30°}{R} \approx 0.726$	M1 A1
	0.73	
		(5)
(c)	After force is removed	
	$R = 4g\cos 30°$	B1
	$-\mu 4g\cos 30° - 4g\sin 30° = 4a$	M1 A1
	$a = (-)11.06\ ...$	
	$v^2 = u^2 + 2as \Rightarrow 0^2 = 16^2 - 2\times 11.06\ ...\times s$	M1
	$s = \dfrac{16^2}{2\times 11.06\ ...} \approx 11.6 \quad (\text{m})$	A1
	12	
		(5)
		(14 marks)

Examiner reports

Question 1

This proved to be a good starter and was well-answered by the majority of candidates. In part (a), most knew that impulse = change in momentum and almost all errors were with the signs. Candidates would be well-advised to put impulses, with arrows, on their diagrams as well as velocities. There are still some candidates giving a negative answer for a magnitude which always loses a mark. Most used conservation of momentum in part (b) which was preferable since it did not rely on their answer from the previous part. Those who used impulse = change in momentum again, applied to the other particle, could lose two marks if their answer to part (a) was wrong.

Question 2

Notwithstanding the usual sign errors, this question was more successfully answered than in some previous years.

Part (a)

Sign errors were frequent for this part with $I = 0.3(8-2) = 1.8$ being frequently seen. An extra g was not often seen but knowledge of the units for impulse – although not separately marked this time – was tenuous, with N or even N/s being proffered. The requirement for "magnitude" demands a positive answer ["(-)3" was marked down, as being an attempt to have it both ways].

Part (b)

Almost all candidates were able to write down a momentum equation (even if with sign errors) but $6m = 3$ far too often led to the deduction $m = 2$. Sign errors could lead to a negative mass, an outcome which should have alerted candidates to a problem; just dropping the negative sign should not be an option!

Question 3

Almost all candidates scored full marks for part (a), with a few extending their graph beyond the line $t = 84$ and a very small minority leaving out V. Similarly the vast majority also obtained full marks in part (b). In the third part a significant number of candidates wrote down $\frac{1}{2}(5-v)20 = 90$. Sometimes it was clear that this was an attempt at finding the area of a trapezium, sometimes it was clearly the area of a triangle (occasionally accompanied by a helpful explanatory diagram) and sometimes one could not be sure. Occasionally one suspected that it was an application of the most commonly used wrong *suvat* formula $s = \frac{1}{2}(v-u)t$.

In the final part, virtually all candidates subtracted the relevant velocities and divided by the time to find the deceleration; those who found the velocity erroneously in part (c) could not achieve the final accuracy mark. This mark also required a positive value for the deceleration.

Question 4

This question was well answered by many candidates.

Part (a)

Almost all drew a graph with the correct relevant sections, and most labelled the significant values on the axes.

Part (b)

A few candidates tried to apply the constant acceleration formulae to more than one section of the motion at a time, showing a complete lack of understanding of the problem and received no credit.. However, most tried to equate the area under the graph to the given distance, many successfully, but there were errors seen. These included treating the first two sections as a single trapezium (despite having five sides), using a wrong value for at least one of the dimensions, omitting a part (e.g. using just a triangle rather than either a trapezium or triangle and rectangle for the middle section), and omitting the '1/2' from the triangle area formula. Those candidates who approached the problem systematically and who made good use of brackets tended to complete the simplification correctly and reach the required answer of 11 m s^{-1}.

Part (c)

Many recognised a valid approach here by either using $v = u + at$ (or a combination of other constant acceleration formulae) or using the fact that the gradient represents the acceleration. Some candidates who did not gain any credit in (b) because of an invalid method often managed to achieve two out of the three available marks here by following through with their wrong V value. The many candidates who produced fully correct solutions thus far sometimes failed to achieve the final mark by giving their answer as negative when the (positive) deceleration was required.

Question 5

Part (a)

n a number of cases the vertical component of the tension was missing; a few missed out the weight, and a small minority "resolved" it. Some mixed up sine and cosine and a few subtracted 40 from 90 to give 60. There was some very poor algebraic manipulation, going from a correct first statement, to an incorrect value for R. *Part (b)* Most candidates earned the B mark, for knowing that $F=uR$ and the majority could get F =1.2cos40 (or 1.2 sin40) and so, even getting part (a) completely incorrect, could gain 5 out of 6 marks for (b). As usual, rounding and accuracy, when using g, caused some problems

Question 6

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 7

Most candidates, in the first part, made a decent attempt at resolving perpendicular to the plane, although a common error was to give the final answer to too many significant figures. Thus candidates should be reminded that answers that emanate from the use of the numerical value of ‘g’ should be given to either 2 or 3 significant figures. In part (b) the most common error was to get the direction of friction wrong, although this only happened in a minority of responses. Early rounding also led to some candidates being penalised for inaccurate values at the end.

Relatively few candidates identified the change in R for the final part of this question and many of those who did often then used $4g\sin 30 - \mu R = 4a$, losing a mark for the sign error. A large number of candidates showed the original value of F being used in otherwise correct equations, gaining the final two M marks only.

Statistics for M1 Practice Paper Bronze Level B4

Original paper	Qu	Mean score	Max score	Mean %	Mean score for students achieving grade: ALL	A	B	C	D	E	U
1001	**1**	5.12	6	85	5.12	5.54	5.21	4.93	4.59	3.90	2.77
0706	**2**	5.47	7	78	5.47	6.63	6.08	5.58	4.88	4.15	2.31
1106	**3**	9.43	12	79	9.43	11.20	10.23	9.28	8.29	7.03	4.60
0706	**4**	8.71	11	79	8.71	10.43	9.67	8.75	7.72	6.50	4.35
0706	**5**	7.10	10	71	7.10	9.30	8.34	6.96	5.49	3.88	1.84
1101	**6**	11.01	15	73	11.01	13.17	11.50	9.34	6.96	4.96	1.80
1201	**7**	8.82	14	63	8.82	10.47	8.91	7.30	6.19	4.71	2.36
		55.66	**75**	**74**	**55.66**	**66.74**	**59.94**	**52.14**	**44.12**	**35.13**	**20.03**