Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Bronze Level B3

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 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
71	65	59	52	46	39

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)

January 2010

2.

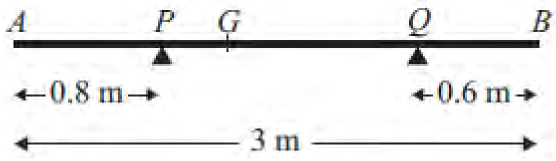

Figure 1

A non-uniform rod AB has length 3 m and mass 4.5 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at P and at Q, where AP = 0.8 m and QB = 0.6 m, as shown in Figure 1. The centre of mass of the rod is at G. Given that the magnitude of the reaction of the support at P on the rod is twice the magnitude of the reaction of the support at Q on the rod, find

(*a*) the magnitude of the reaction of the support at Q on the rod,

(3)

(*b*) the distance AG.

(4)

May 2012

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3. A particle P of mass 0.4 kg moves under the action of a single constant force **F** newtons. The acceleration of P is $(6\mathbf{i} + 8\mathbf{j})$ m s^{-2}. Find

(*a*) the angle between the acceleration and **i**,

(2)

(*b*) the magnitude of **F**.

(3)

At time t seconds the velocity of P is **v** m s^{-1}. Given that when $t = 0$, $\mathbf{v} = 9\mathbf{i} - 10\mathbf{j}$,

(*c*) find the velocity of P when $t = 5$.

(3)

May 2008

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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)

June 2007

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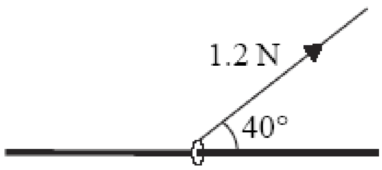
5. **Figure 2**



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 2. 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)

June 2007

6.

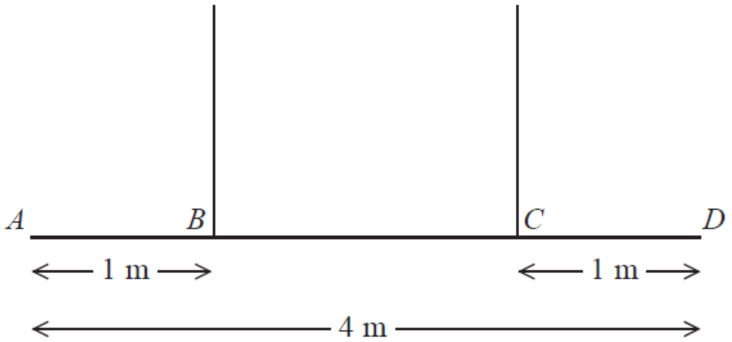


Figure 3

A non-uniform beam AD has weight W newtons and length 4 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. The ropes are attached to two points B and C on the beam, where AB = 1 m and CD = 1 m, as shown in Figure 3. The tension in the rope attached to C is double the tension in the rope attached to B. The beam is modelled as a rod and the ropes are modelled as light inextensible strings.

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

(6)

A small load of weight kW newtons is attached to the beam at D. The beam remains in equilibrium in a horizontal position. The load is modelled as a particle.

Find

(*b*) an expression for the tension in the rope attached to B, giving your answer in terms of k and W,

(3)

(*c*) the set of possible values of k for which both ropes remain taut.

(2)

June 2014 (R)

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7. A particle P is moving with constant velocity. The position vector of P at time t seconds ($t \geq 0$) is $\mathbf{r}$ metres, relative to a fixed origin O, and is given by

$$\mathbf{r} = (2t - 3)\mathbf{i} + (4 - 5t)\mathbf{j}.$$

(*a*) Find the initial position vector of P.

(1)

The particle P passes through the point with position vector $(3.4\mathbf{i} - 12\mathbf{j})$ m at time T seconds.

(*b*) Find the value of T.

(3)

(*c*) Find the speed of P.

(4)

June 2015

8.

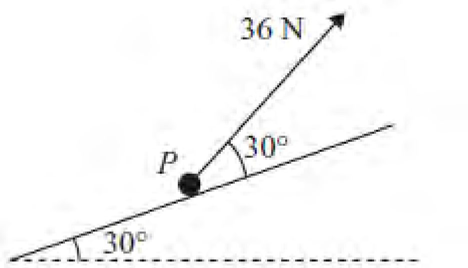


Figure 4

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 4. 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.

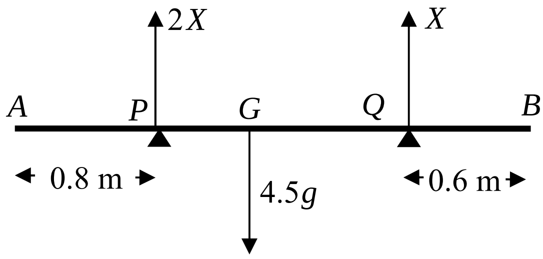
(c) Find the distance that P travels between the instant when the force is removed and the instant when it comes to rest.

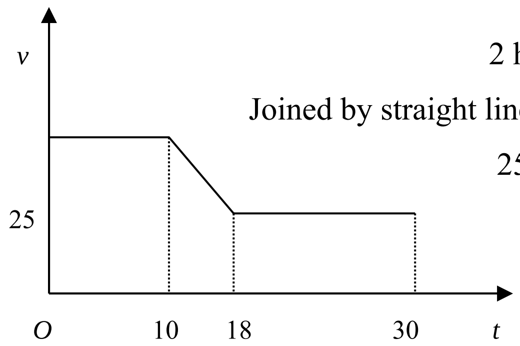
(5)

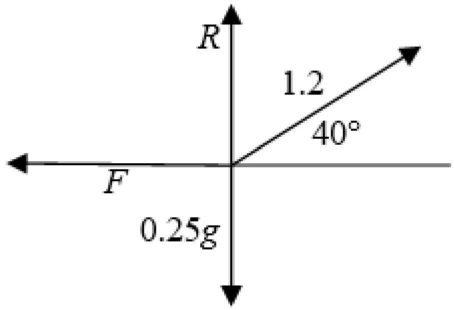
January 2012

TOTAL FOR PAPER: 75 MARKS

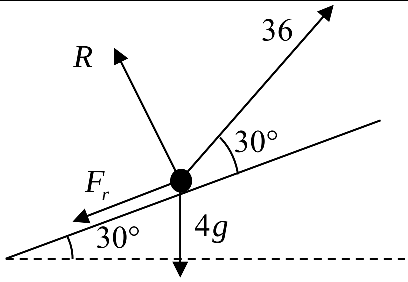
END

Question number	Scheme	Marks
1 (a)	$I = 2\times12 - 2\times3 = 18\ (\text{N s})$	M1 A1
		(2)
(b)	LM $\quad 2\times12 - 8m = 2\times3 + 4m$	M1 A1
	Solving to $m = 1.5$	DM1 A1
		(4)
		[6]
	Alternative to (b)	
	$I = m\left(4 - (-8)\right) = 18$	M1 A1
	Solving to $m = 1.5$	DM1 A1
		(4)
2 (a)		
	$\uparrow \quad 2X + X = 4.5g$	M1 A1
	Leading to $X = \dfrac{3g}{2}$ or 14.7 or 15 (N)	A1
		(3)
(b)	$\text{M}(A) \quad 4.5g\times AG = (2X)\times0.8 + X\times2.4$	M1 A2 **ft** (1,0)
	$AG = \dfrac{4}{3}\ (\text{m}),\ 1.3,\ 1.33,\ldots$	A1
		(4)
		[7]

Question number	Scheme	Marks
3 (a)	$\tan\theta = \frac{8}{6}$	M1
	$\theta \approx 53°$	A1
		(2)
(b)	$\mathbf{F} = 0.4(6\mathbf{i}+8\mathbf{j})\ (= 2.4\mathbf{i}+3.2\mathbf{j})$	M1
	$\lvert\mathbf{F}\rvert = \sqrt{(2.4^2+3.2^2)} = 4$	M1 A1
		(3)
(c)	$\mathbf{v} = 9\mathbf{i}-10\mathbf{j}+5(6\mathbf{i}+8\mathbf{j})$	M1 A1
	$= 39\mathbf{i}+30\mathbf{j}\ (\text{ms}^{-1})$	A1
		(3)
		[8]
4 (a)		
	2 horizontal lines	B1
	Joined by straight line sloping down	B1
	25, 10, 18, 30 oe	B1
		(3)
(b)	$25\times10+\underline{\tfrac{1}{2}(25+V)\times8}+12\times V = 526$	M1 <u>A1</u> A1
	Solving to $V = 11$	DM1 A1
		(5)
(c)	"$v = u+at$" $\Rightarrow$ $11 = 25-8a$ ft their V	M1 A1ft
	$a = 1.75\ (\text{m s}^{-2})$	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]
6 (a)	Resolving vertically: $T + 2T\,(= 3T) = W$	M1A1
	Moments about B: $2 \times 2T = (d-1)W$	M1A1
	Substitute and solve for d : $2 \times 2T = (d-1)3T$	**D**M1
	$d = \frac{7}{3}$ (m)	A1
		(6)
(b)	Moments about C: $(T_B \square 2) + (kW \square 1) = W \square \frac{2}{3}$	M1A1
	$T_B = W\frac{(2-3k)}{6}$ or equivalent	A1
		(3)
(c)	solving $T_B \geq 0$ or $T_B > 0$ for k.	M1
	$0 < k \leq 2/3$ or $0 < k < 2/3$ only	A1
		(2)
		[11]

Question number	Scheme	Marks
7 (a)	$\mathbf{r} = (-3\mathbf{i} + 4\mathbf{j})$ m	B1 **(1)**
(b)	$3.4 = 2T - 3$ or $-12 = 4 - 5T$ $T = 3.2$	M1 A1 A1 **(3)**
(c)	$\mathbf{r} = (-3\mathbf{i} + 4\mathbf{j}) + t(2\mathbf{i} - 5\mathbf{j})$ $\mathbf{v} = (2\mathbf{i} - 5\mathbf{j})$	M1 A1
	speed $= \sqrt{\left(2^2 + (-5)^2\right)} = \sqrt{29} = 5.4\text{m s}^{-1}$ or better	M1 A1 **(4)** **[8]**

Question number	Scheme	Marks
8 (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
	$\mu = \dfrac{36\cos 30° - 4g\sin 30°}{R} \approx 0.726$ 0.73	M1 A1
		(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
	$s = \dfrac{16^2}{2\times 11.06\ ...} \approx 11.6\quad (\text{m})$ 12	A1
		(5)
		[14]

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

In part (a) the majority of candidates used the most direct method of resolving forces to find the reaction at Q. Usually the information was interpreted correctly with the reaction at P being twice that at Q; however, occasionally they were reversed which led to the loss of two accuracy marks for the whole question if the rest of the working was consistent and accurate. Virtually all candidates correctly included 'g' in the weight term. A small number attempted moments equations but, since this required the solution of two simultaneous equations, errors were more prevalent. Those who only produced one equation and assumed G was at the midpoint achieved no credit. Part (b) did require a moments equation (about any point, but 'A' or 'P' were the most usual). Sometimes working was not clear and a relevant unknown distance not defined. This led to some candidates giving their final answer as '0.533..' which was in fact PG. Since AG was specifically asked for in the question, a statement of 'x = 1.33..' was not considered sufficient for the final mark unless 'x' had been defined previously or clearly shown on a diagram. At least 2 significant figure accuracy was acceptable including exact fractions (since 'g' cancelled). Generally this question was done well and full marks were often seen.

Question 3

This question was done well by the vast majority of candidates. Most used trigonometry appropriately in part (a) to find the required angle. In the second part some used $\boldsymbol{F} = m\mathbf{a}$ correctly but failed to find the magnitude, whereas others found the magnitude of the given acceleration vector (sometimes labelling it as the force) but did not go on to multiply by the mass. Many used the relevant vector constant acceleration formula to achieve a correct velocity in the final part, although occasionally candidates multiplied the velocity rather than the acceleration by 5, or they tried to convert it all into scalars.

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). In 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
The first part was answered very well by the vast majority but in part (b) most marks lost were due to students assuming that $T_C = 2T_B$ from part (a). The final part was poorly done by most and a lot of students used an = sign in their working and substituted the inequality at the end which lost marks.

Question 7
In part (a), the vast majority of candidates identified correctly the initial position vector. Most were able to equate one (or both) components to calculate the required time in the second part. Some who attempted to find the ratio of the displacement vector to the velocity vector gave an answer for T (time) as a vector (for example 3.2**i** + 3.2**j**), showing a lack of understanding of vector quantities. There were two main alternative approaches to completing part (c). Those who identified **v** = 2**i** – 5**j** from the given expression almost invariably went on to use Pythagoras correctly to find the required speed. However, those who attempted a distance (or displacement) divided by a time tended to be less successful; errors seen included using the wrong displacement (in particular the given 3.4**i** – 12**j**), or confusing displacement and velocity. Occasionally, the velocity vector 2**i** – 5**j** , rather than the speed, was given as the final answer, but such cases were relatively rare and many fully correct solutions were seen. Full marks for this question were rare with a significant number of candidates achieving little or no credit.

Question 8
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 B3

				Mean score for students achieving grade:							
Qu	**Max score**	**Modal score**	**Mean %**	**ALL**	**A***	**A**	**B**	**C**	**D**	**E**	**U**
1	6		85	5.12		5.54	5.21	4.93	4.59	3.90	2.77
2	7		78	5.48	6.81	6.65	6.24	5.63	4.77	3.62	1.63
3	8		75	6.03		7.43	6.64	5.93	5.18	4.30	2.59
4	11		79	8.71		10.43	9.67	8.75	7.72	6.50	4.35
5	10		71	7.10		9.30	8.34	6.96	5.49	3.88	1.84
6	11		64	7.02	9.30	8.29	6.70	6.44	5.38	3.84	2.28
7	8	8	72	5.77	7.69	7.36	6.46	5.44	4.42	3.16	1.73
8	14		63	8.82	11.56	10.47	8.91	7.30	6.19	4.71	2.36
	75		**72.07**	**54.05**	**35.36**	**65.47**	**58.17**	**51.38**	**43.74**	**33.91**	**19.55**