Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1
Bronze Level B3

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 $g = 9.8$ 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
73	66	60	50	40	32

1. Two particles P and Q have mass 0.4 kg and 0.6 kg respectively. The particles are initially at rest on a smooth horizontal table. Particle P is given an impulse of magnitude 3 N s in the direction PQ.

(a) Find the speed of P immediately before it collides with Q.

(3)

Immediately after the collision between P and Q, the speed of Q is 5 m s^{-1}.

(b) Show that immediately after the collision P is at rest.

(3)

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2. Two particles A and B, of mass $5m$ kg and $2m$ kg respectively, are moving in opposite directions along the same straight horizontal line. The particles collide directly. Immediately before the collision, the speeds of A and B are 3 m s^{-1} and 4 m s^{-1} respectively. The direction of motion of A is unchanged by the collision. Immediately after the collision, the speed of A is 0.8 m s^{-1}.

(a) Find the speed of B immediately after the collision.

(3)

In the collision, the magnitude of the impulse exerted on A by B is 3.3 N s.

(b) Find the value of m.

(3)

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3. A steel girder AB, of mass 200 kg and length 12 m, rests horizontally in equilibrium on two smooth supports at C and at D, where AC = 2 m and DB = 2 m. A man of mass 80 kg stands on the girder at the point P, where AP = 4 m, as shown in Figure 1.

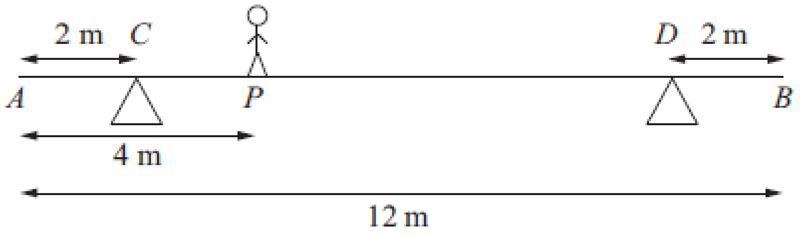

Figure 1

The man is modelled as a particle and the girder is modelled as a uniform rod.

(a) Find the magnitude of the reaction on the girder at the support at C.

(3)

The support at D is now moved to the point X on the girder, where $XB = x$ metres. The man remains on the girder at P, as shown in Figure 2.

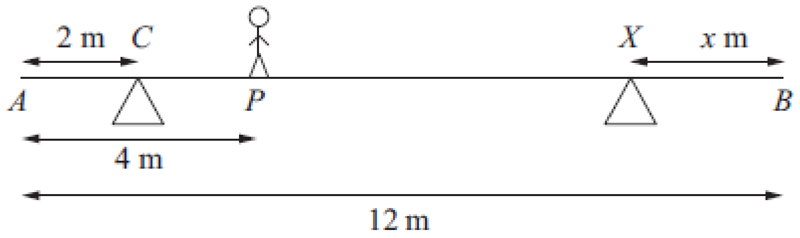

Figure 2

Given that the magnitudes of the reactions at the two supports are now equal and that the girder again rests horizontally in equilibrium, find

(b) the magnitude of the reaction at the support at X,

(2)

(c) the value of x.

(4)

4.

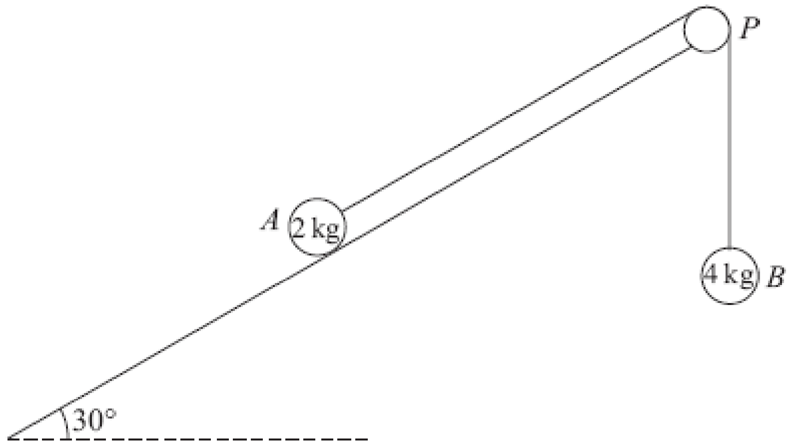

Figure 2

A fixed rough plane is inclined at 30° to the horizontal. A small smooth pulley *P* is fixed at the top of the plane. Two particles *A* and *B*, of mass 2 kg and 4 kg respectively, are attached to the ends of a light inextensible string which passes over the pulley *P*. The part of the string from *A* to *P* is parallel to a line of greatest slope of the plane and *B* hangs freely below *P*, as shown in Figure 2. The coefficient of friction between *A* and the plane is $\frac{1}{\sqrt{3}}$. Initially *A* is held at rest on the plane. The particles are released from rest with the string taut and *A* moves up the plane.

Find the tension in the string immediately after the particles are released.

(9)

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5. A small brick of mass 0.5 kg is placed on a rough plane which is inclined to the horizontal at an angle θ, where $\tan\theta = \frac{4}{3}$, and released from rest. The coefficient of friction between the brick and the plane is $\frac{1}{3}$.

Find the acceleration of the brick.

(9)

6.

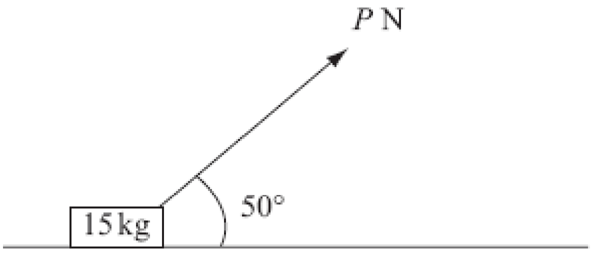

Figure 1

A small box of mass 15 kg rests on a rough horizontal plane. The coefficient of friction between the box and the plane is 0.2 . A force of magnitude P newtons is applied to the box at 50° to the horizontal, as shown in Figure 1. The box is on the point of sliding along the plane.

Find the value of P, giving your answer to 2 significant figures.

(9)

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7. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given with respect to a fixed origin.*]

A ship S is moving with constant velocity $(-12\mathbf{i} + 7.5\mathbf{j})$ km h^{-1}.

(*a*) Find the direction in which S is moving, giving your answer as a bearing.

(3)

At time t hours after noon, the position vector of S is $\mathbf{s}$ km. When $t = 0$, $\mathbf{s} = 40\mathbf{i} - 6\mathbf{j}$.

(*b*) Write down $\mathbf{s}$ in terms of t.

(2)

A fixed beacon B is at the point with position vector $(7\mathbf{i} + 12.5\mathbf{j})$ km.

(*c*) Find the distance of S from B when $t = 3$.

(4)

(*d*) Find the distance of S from B when S is due north of B.

(4)

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8. A boat B is moving with constant velocity. At noon, B is at the point with position vector $(3\mathbf{i} - 4\mathbf{j})$ km with respect to a fixed origin O. At 1430 on the same day, B is at the point with position vector $(8\mathbf{i} + 11\mathbf{j})$ km.

(*a*) Find the velocity of B, giving your answer in the form $p\mathbf{i} + q\mathbf{j}$.

(3)

At time t hours after noon, the position vector of B is $\mathbf{b}$ km.

(*b*) Find, in terms of t, an expression for $\mathbf{b}$.

(3)

Another boat C is also moving with constant velocity. The position vector of C, $\mathbf{c}$ km, at time t hours after noon, is given by

$$\mathbf{c} = (-9\mathbf{i} + 20\mathbf{j}) + t(6\mathbf{i} + \lambda\mathbf{j}),$$

where λ is a constant.

Given that C intercepts B,

(*c*) find the value of λ,

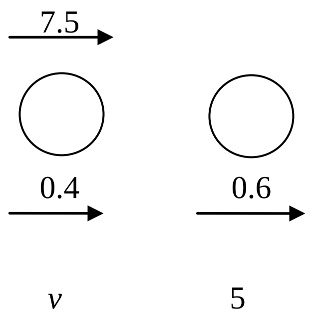
(5)

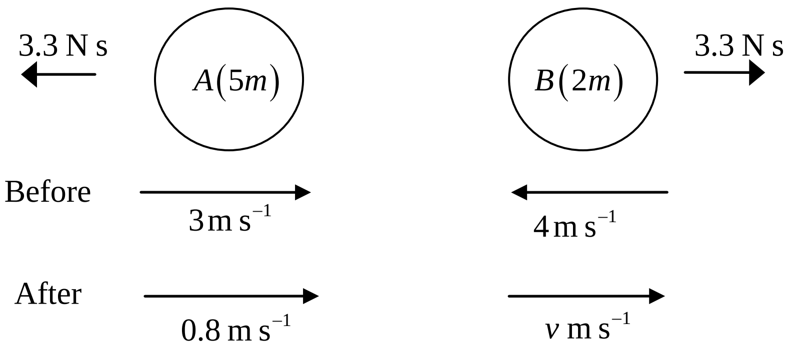
(*d*) show that, before C intercepts B, the boats are moving with the same speed.

(3)

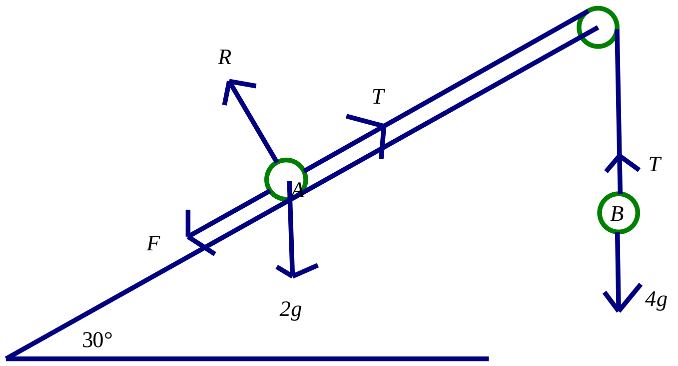
TOTAL FOR PAPER: 75 MARKS

END

Question Number		*Scheme*	**Marks**
1.	(*a*)	$I = mv \quad \Rightarrow \quad 3 = 0.4 \times v$	M1 A1
		$v = 7.5 \ \left(\text{ms}^{-1}\right)$	A1 (3)
	(*b*)		
		LM $\quad 0.4 \times 7.5 = 0.4v + 0.6 \times 5$	M1 A1
		$0 = 0.4v \quad \Rightarrow \quad v = 0$ ***** cso	A1 cso (3)
			(6 marks)

Question Number	Scheme	Marks
2.		
	(a) CLM $\quad 5m \times 3 - 2m \times 4 = 5m \times 0.8 + 2mv$	M1 A1
	Leading to $v = 1.5$ $\left(\text{Speed is } 1.5 \text{ m s}^{-1}\right)$	A1 **(3)**
	(b) Impulse for A $\quad 5m(0.8 - 3) = -3.3$	M1 A1
	Leading to $m = 0.3$	A1 **(3)**
		[6]

Question Number	Scheme	Marks
3. (a)	$M(D)$, $\quad 8R = (80g \text{ x } 6) + (200g \text{ x } 4)$ $R = 160g,\ 1600,\ 1570$	M1 A1 A1 (3)
(b)	$(\uparrow)$, $\quad 2S = 80g + 200g$ $S = 140g,\ 1400,\ 1370$	M1 A1 (2)
(c)	$M(B)$, $\quad Sx + (S \text{ x } 10) = (80g \text{ x } 8) + (200g \text{ x } 6)$ $140x + 1400 = 640 + 1200$ $140x = 440$ $x = \frac{22}{7}$	M1 A2 A1 (4) **9**

Question Number	Scheme	Marks
4.	 Equation of motion of B: $\quad 4g - T = 4a$ Equation of motion of A: $\quad T - F - 2g\sin 30 = 2a$ OR: $\ 4g - F - 2g\sin 30 = 6a$ Resolve perpendicular to the plane at A: $\quad R = 2g\cos 30$ Use of $F = \mu R$: $\ F = \frac{1}{\sqrt{3}} \times 2g\cos 30 (= g)$ $T - g - g = T - 2g = 2a$ $2T - 4g = 4g - T,\ \ 3T = 8g,\ \ T = \frac{8g}{3} (\approx 26)\ 26.1(\text{N})$	M1A1 M1A2 B1 M1 **DM1**A1 **(9)** **[9]**

Question Number	Scheme	Marks
5.	$0.5g\sin\theta - F = 0.5a$	M1 A1 A1
	$F = \frac{1}{3}R$ seen	B1
	$R = 0.5g\cos\theta$	M1 A1
	Use of $\sin\theta = \frac{4}{5}$ or $\cos\theta = \frac{3}{5}$ or decimal equiv or decimal angle e.g 53.1^{o} or 53^{o}	B1
	$a = \dfrac{3g}{5}$ or 5.88 m s^{-2} or 5.9 m s^{-2}	DM1 A1 **[9]**
		(9 marks)

6.	$F = P\cos 50^{o}$	M1 A1
	$F = 0.2R$ seen or implied.	B1
	$P\sin 50^{o} + R = 15g$	M1 A1 A1
	Eliminating *R*; Solving for *P* ; *P* = 37 (2 SF)	M1; M1;A1
		(9 marks)

7.	(a) $\arctan\dfrac{7.5}{12} = 32°$	M1 A1
	Bearing is 302 (allow more accuracy)	A1 **(3)**
	(b) $\mathbf{s} = 40\mathbf{i} - 6\mathbf{j} + t(-12\mathbf{i} + 7.5\mathbf{j})$	M1 A1 **(2)**
	(c) $t = 3$, $\mathbf{s} = 4\mathbf{i} + 16.5\mathbf{j}$	M1
	$\mathbf{s} - \mathbf{b} = -3\mathbf{i} + 4\mathbf{j}$	M1
	$SB = \sqrt{\left((-3)^2 + 4^2\right)} = 5$ (km)	DM1 A1 **(4)**
	(d) Equating **i** components	
	$40 - 12t = 7$ **or** $-33 + 12t = 0$	M1
	$t = 2\dfrac{3}{4}$	A1
	When $t = 2\dfrac{3}{4}$, $\mathbf{s} = (7\mathbf{i}) + 14\dfrac{5}{8}\mathbf{j}$	M1
	$SB = 2\dfrac{1}{8}$ (km) 2.125, 2.13	A1 **(4)**
		[13]

Question Number	Scheme	Marks
8.	(a) $\mathbf{v} = \dfrac{8\mathbf{i}+11\mathbf{j}-(3\mathbf{i}-4\mathbf{j})}{2.5}$ or any equivalent	M1 A1
	$\mathbf{v} = 2\mathbf{i}+6\mathbf{j}$	A1 **(3)**
	(b) $\mathbf{b} = 3\mathbf{i}-4\mathbf{j}+\mathbf{v}t$ ft their $\mathbf{v}$	M1 A1 ft
	$= 3\mathbf{i}-4\mathbf{j}+(2\mathbf{i}+6\mathbf{j})t$	A1cao **(3)**
	(c) $\mathbf{i}$ component: $-9+6t = 3+2t$	M1
	$t = 3$	M1 A1
	$\mathbf{j}$ component: $20+3\lambda = -4+18$	M1
	$\lambda = -2$	A1 **(5)**
	(d) $v_B = \sqrt{(2^2+6^2)}$ or $v_C = \sqrt{(6^2+(-2)^2)}$	M1
	Both correct	A1
	The speeds of B and C are the same cso	A1 **(3)** **[14]**

Examiner reports

Question 1

This was done well by the majority of candidates. Part (a) was a straightforward opening question, almost always correctly answered. A few candidates wrote $3 = 0.4(0 - v)$, thus only gaining the method mark. In the second part most knew and could apply appropriately the conservation of momentum principle, with only occasional sign errors. Drawing a clear velocity diagram would have helped candidates who confused ‘before’ and ‘after’ velocities. Since it was a ‘show that’ question it was important that full working was seen in order to achieve full marks. Wordy explanations involving impulses with no equation, tended to achieve no marks.

Question 2

The vast majority of candidates wrote down an appropriate equation for ‘conservation of linear momentum’ in part (a) and proceeded to calculate the required speed. Although there were occasional sign errors, numerical slips or miscopying errors, these were fairly rare and most candidates achieved the correct answer. Equating equal but opposite impulses was an alternative valid approach but was seldom seen. In part (b), most knew a correct formula for ‘impulse’ in terms of change in momentum on one particle, but often the direction was not properly accounted for; this often led to a negative value for ‘m’ (with the minus sign just being dropped ‘because mass has to be positive’). If the impulse on particle B was used, a correct value for the velocity from part (a) was required to be eligible for accuracy marks. Sometimes, a correct formula was quoted but ‘m’ (rather than the relevant ‘$2m$’ or ‘$5m$’) was used as the mass. Occasionally ‘mg’ was quoted in the momentum expressions; this was not penalised in part (a) if the ‘g’ cancelled throughout, but it was treated as a method error in part (b).

Question 3

There were many excellent solutions with the better candidates clearly stating the points about which they were taking moments. Very few candidates produced dimensionally incorrect equations or left out g’s but a significant majority lost an accuracy mark in either (a) or (b). In part (a) the majority chose to take moments about D so finding the reaction in one step. It was helpful to the candidates that, if marks were lost in part (a), this did not prevent them from picking up all of the remaining marks since part (b) led into part (c) and most found part (b) straightforward. Very few fell into the trap of using data from (a) in the ensuing solution and very few had rounding errors in their final answer. Part (c) was surprisingly completely correct in some cases after poor performance in parts (a) and/or (b). Apart from really poor solutions, most marks were lost through using incorrect distances when taking moments. However there were some good accurate alternative solutions to part (c) showing competent use of algebra, with candidates choosing to take taking moments about a variety of points, with B and C being the most popular.

Question 4

The vast majority had little difficulty with this question with the most common error being over specification of the final answer. Candidates should be reminded to round to an appropriate degree of accuracy when the numerical value of g (9.8) has been used to calculate an answer (see above). Most considered the two particles separately but occasionally a ‘whole system’ equation was seen and candidates are reminded that this approach is discouraged.

Question 5

This question was well done by the majority of candidates. Most made valid attempts at resolving parallel and perpendicular to the plane. The most common error was where candidates obtained the sin/cos of the complementary angle. Others used sin(4/5) or cos(3/5). Many successful candidates used the actual angle 53.1 rather than working with fractions for the trig. ratios. Some thought that the friction force was 1/3. A few managed to obtain the "correct" answer fortuitously by using $R = 0.5a$.

Question 6

Most candidates scored three marks for $F = P\cos 50°$ and for $F = 0.2R$. However, errors were often made in the vertical resolution, with some ignoring P completely, giving $R = 15g$, while others included a component of P but made a sign error. A small minority of candidates was unable to eliminate R legitimately between their equations, while a significant number lost the final A1 for giving the answer as 36.9 (or 36.93).

Question 7

In part (a) since only the velocity was stated, virtually all candidates used this vector to identify a relevant angle (generally 32 or 58) using a correct 'arctan'. However, a significant number failed to derive the corresponding bearing (302). In the second part, most stated a correct position vector in terms of t, although occasionally the initial position was omitted or the two vectors were reversed. Part (c) required the substitution of $t = 3$ and the subtraction of the two position vectors. The majority substituted first and generally found a correct vector. However, some did not attempt to find the magnitude of the displacement to calculate the distance between B and S as required. Although in part (d) many candidates correctly equated **i** components to determine the time when S was due North of B, some either equated **j** components or, more commonly, equated to zero, the **i** component of the position vector of S. Those who reached a value for t generally substituted it into the position vector for S but sometimes left their final answer as '14.625' rather than subtracting 12.5 as required. Giving the final answer as '2.125**j**' rather than '2.125' was penalised. There were a large number of entirely correct solutions seen, but there were also a fair number of candidates who made little clear progress in part (d).

Question 8

There was some evidence that a number of weaker candidates were unable to complete this question but it wasn't clear whether they ran out of time or simply couldn't do it.
In parts (a) and (b) some candidates confused the use of position vectors and velocity vectors.

Part (a)

This was well answered by most candidates. Where errors did occur they often involved adding the position vectors, not dividing by the time or miscalculating the time or else doing the subtraction incorrectly or the wrong way round.

Particular examples:-

errors in dividing by 2.5, particularly the **j**-component of the vector.
errors in time, using 2.3 or 4.5 hours.
some candidates changed the time into minutes, others into seconds.

not enough care was taken in looking at the compatibility of length and time units.
use of inappropriate formulae to solve the problem .

A few candidates clearly did not know how to deal with it at all.

Part (b)

This was often correct. Errors that did occur were usually in the position vector, either using 8**i** +11**j** or else leaving it out completely. Also some candidates used a position vector for **v**. A few candidates found the speed or velocity. However for those who had an answer to part (a) most were successful in carrying it correctly forward into this part.

Part (c)

Most knew they had to equate the position vectors but a number did not then go on to equate coefficients of **i** and **j**. Those that did were largely successful in getting the right values out. Others tried to solve the equation for by crossing out all the 't's or all the '**i**'s and '**j**'s. Some tried to divide vectors whilst others just substituted in random values for t.

*Part (d)*Relatively few got full marks here. Most ,who got part (a) correct ,were able to get the first mark. Common errors seen were finding the position at $t = 3$ and then using Pythagoras, or else using **v** x t. Some candidates just stated that the vectors were the same. Many of those who did carry out the correct calculations either left it at that, without making a statement, or else declared that the velocities rather than the speeds were equal. There were a few instances where 6**i** + 2**j** was taken as the second speed, with no obvious connection to their previous work, using the fact that the speeds must be equal! A few also guessed λ in part (d) and then placed this value at the end of a page of incomprehensible working in part (c).

Statistics for M1 Practice Paper Bronze Level B3

Original paper	Qu	Mean score	Max score	Mean %	Mean score for students achieving grade: ALL	A	B	C	D	E	U
0806	**1**	4.85	6	81	4.85	5.64	5.31	4.97	4.46	3.95	2.30
1206	**2**	4.46	6	74	4.46	5.27	4.81	4.45	4.08	3.54	2.11
1301	**3**	6.62	9	74	6.62	7.96	6.95	5.73	4.47	2.88	1.55
1306R	**4**	6.73	9	75	6.73	7.98	7.09	5.74	4.21	3.79	1.72
0906	**5**	6.89	9	77	6.89	8.52	7.76	6.88	5.64	4.67	2.24
0906	**6**	6.01	9	67	6.01	8.05	6.87	5.75	4.48	3.25	1.37
1206	**7**	8.69	13	67	8.69	11.80	10.00	8.07	6.25	4.44	1.96
0706	**8**	8.17	14	58	8.17	12.33	9.21	6.99	5.01	3.32	1.57
		55.92	**75**	**75**	**52.42**	**67.55**	**58.00**	**48.58**	**38.60**	**29.84**	**14.82**