Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1
Silver Level S1

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 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	63	56	47	36	29

1. Two particles A and B have masses 4 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 5 m s^{-1} and the speed of B is 3 m s^{-1}. Immediately after the collision, the direction of motion of A is unchanged and the speed of A is 1 m s^{-1}.

(*a*) Find the magnitude of the impulse exerted on A in the collision.

(2)

Immediately after the collision, the speed of B is 2 m s^{-1}.

(*b*) Find the value of m.

(4)

---

2. Particle P has mass m kg and particle Q has mass $3m$ kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision P has speed $4u \text{ m s}^{-1}$ and Q has speed $ku \text{ m s}^{-1}$, where k is a constant. As a result of the collision the direction of motion of each particle is reversed and the speed of each particle is halved.

(*a*) Find the value of k.

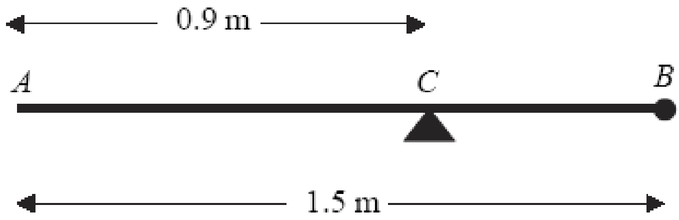
(4)

(*b*) Find, in terms of m and u, the magnitude of the impulse exerted on P by Q.

(3)

3.

Figure 3



A uniform rod AB has length 1.5 m and mass 8 kg. A particle of mass m kg is attached to the rod at B. The rod is supported at the point C, where AC = 0.9 m, and the system is in equilibrium with AB horizontal, as shown in Figure 2.

(*a*) Show that $m = 2$.

(4)

A particle of mass 5 kg is now attached to the rod at A and the support is moved from C to a point D of the rod. The system, including both particles, is again in equilibrium with AB horizontal.

(*b*) Find the distance AD.

(5)

---

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)

---

5. A plank PQR, of length 8 m and mass 20 kg, is in equilibrium in a horizontal position on two supports at P and Q, where $PQ = 6$ m.

A child of mass 40 kg stands on the plank at a distance of 2 m from P and a block of mass M kg is placed on the plank at the end R. The plank remains horizontal and in equilibrium. The force exerted on the plank by the support at P is equal to the force exerted on the plank by the support at Q.

By modelling the plank as a uniform rod, and the child and the block as particles,

(*a*) (i) find the magnitude of the force exerted on the plank by the support at P,

(ii) find the value of M.

(10)

(*b*) State how, in your calculations, you have used the fact that the child and the block can be modelled as particles.

(1)

---

5. Two cars P and Q are moving in the same direction along the same straight horizontal road. Car P is moving with constant speed 25 m s^{-1}. At time $t = 0$, P overtakes Q which is moving with constant speed 20 m s^{-1}. From $t = T$ seconds, P decelerates uniformly, coming to rest at a point X which is 800 m from the point where P overtook Q. From $t = 25$ s, Q decelerates uniformly, coming to rest at the same point X at the same instant as P.

(*a*) Sketch, on the same axes, the speed-time graphs of the two cars for the period from $t = 0$ to the time when they both come to rest at the point X.

(4)

(*b*) Find the value of T.

(8)

---

6. [*In this question, the unit vectors* **i** *and* **j** *are due east and due north respectively. Position vectors are relative to a fixed origin O.*]

A ship sets sail at 9 a.m. from a port *P* and moves with constant velocity. The position vector of *P* is (4**i** – 8**j**) km. At 9.30 a.m. the ship is at the point with position vector (**i** – 4**j**) km.

(*a*) Find the speed of the ship in km h^{-1}.

(4)

(*b*) Show that the position vector **r** km of the ship, *t* hours after 9 a.m., is given by

$$\mathbf{r} = (4 - 6t)\mathbf{i} + (8t - 8)\mathbf{j}.$$

(2)

At 10 a.m. a passenger on the ship observes that a lighthouse *L* is due west of the ship.
At 10.30 a.m. the passenger observes that *L* is now south-west of the ship.

(*c*) Find the position vector of *L*.

(5)

---

7. [*In this question, the horizontal unit vectors* **i** *and* **j** *are directed due east and due north respectively.*]

The velocity, **v** m s^{-1}, of a particle *P* at time *t* seconds is given by

$$\mathbf{v} = (1 - 2t)\mathbf{i} + (3t - 3)\mathbf{j}.$$

(*a*) Find the speed of *P* when $t = 0$.

(3)

(*b*) Find the bearing on which *P* is moving when $t = 2$.

(2)

(*c*) Find the value of *t* when *P* is moving

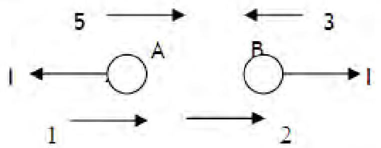
(i) parallel to **j**,

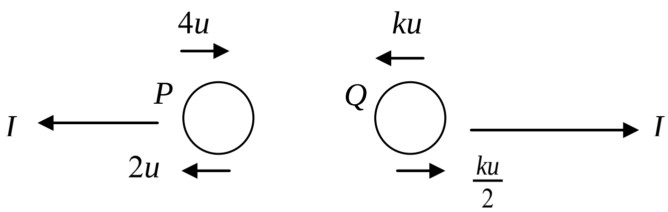
(ii) parallel to (–**i** – 3**j**).

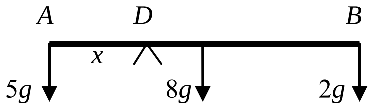
(6)

TOTAL FOR PAPER: 75 MARKS

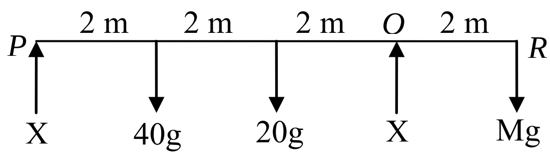
END

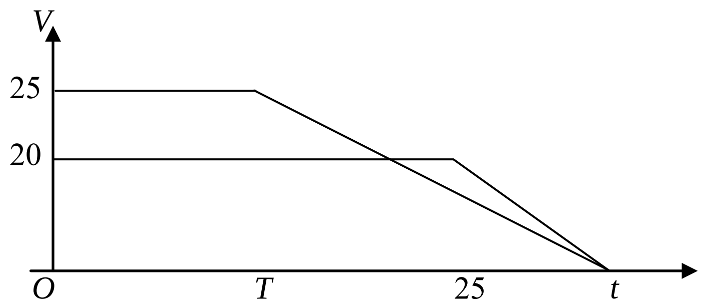
Question Number	Scheme	Marks
1(a)		
	$I = 4(5 - 1) = \underline{16\text{ Ns}}$	M1 A1 (2)
(b)	CLM: $4 \times 5 - m \times 3 = 4 \times 1 + m \times 2$	M1 A1
	$\Rightarrow m = \underline{3.2}$	DM1 A1 (4)
	or	**or**
	$16 = m(3 + 2)$	M1 A1
	$\Rightarrow m = \underline{3.2}$	DM1 A1 (4) **6**

Question Number	Scheme	Marks
Q2 (a)		
	$4mu - 3mku = -2mu + 3mk\frac{u}{2}$	M1 A1
	$k = \frac{4}{3}$	M1 A1cso (4)
(b)	For P, $I = m(2u - -4u)$	M1 A1
	$= 6mu$	A1 (3)
		[7]

Question Number	Scheme	Marks
3.	(a) M(C) $8g \times (0.9 - 0.75) = mg(1.5 - 0.9)$	M1 A1
	Solving to $m = 2$ * cso	DM1 A1 **(4)**
	(b) 	
	M(D) $5g \times x = 8g \times (0.75 - x) + 2g(1.5 - x)$	M1 A2(1, 0)
	Solving to $x = 0.6$ ($AD = 0.6$ m)	DM1 A1 **(5)**
		[9]

4.	(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 marks)

5. **(a)**		
(i)	**EITHER** M(R), $8X + 2X = 40g \times 6 + 20g \times 4$	M1 A2
	solving for X, $X = 32g = 314$ or 310 N	M1 A1
(ii)	($\uparrow$) $X + X = 40g + 20g + Mg$ (or another moments equation)	M1 A2
	solving for M, $M = 4$	M1 A1
(i)	**OR** M(P), $6X = 40g \times 2 + 20g \times 4 + Mg \times 8$	M1 A2
	solving for X, $X = 32g = 314$ or 310 N	M1 A1
	($\uparrow$) $X + X = 40g + 20g + Mg$ (or another moments equation)	M1 A2
(ii)	solving for M, $M = 4$	M1 A1 (10)
(b)	Masses concentrated at a point or weights act at a point	B1 (1) **11**

Q6 (a)	 Shape (both) Cross Meet on t-axis Figures 25,20,T,25	B1 B1 B1 B1 (4)
(b)	For Q: $20\left(\frac{t+25}{2}\right) = 800$	M1 A1
	$t = 55$	**DM1** A1
	For P: $25\left(\frac{T+55}{2}\right) = 800$	M1 A1
	solving for T: $T = 9$	**DM1** A1 (8) **[12]**

4.	$12.6^2 = 2a.50 \quad (\Rightarrow a = 1.5876)$ $800g\sin 15 - F = 800a$ $R = 800g\cos 15$ $F = \mu R$ $800g\sin 15 - \mu 800g\cos 15 = 800 \text{ x } 1.5876$ $\mu = 0.1, 0.10, 0.100$	M1 A1 M1 A1 M1 A1 B1 M1 A1 **9**
5. (a)	$30^2 = 2a.300$ $a = 1.5$	M1 A1 (2)
(b)	$0^2 = 30^2 - 2 \text{ x } 1.25s$ OR $0 = 30 - 1.25t_2$ $s = 360$ $\quad t_2 = 24$ $300 + 30T + 360 = 1500$ $\quad \frac{(20+T+24+T)}{2} \text{ x } 30 = 1500$ $T = 28$ $\quad T = 28$	M1 A1 M1 A1 A1 (5)
(c)	triangle, *drawn on the diagram*, with base coinciding with base of trapezium, top vertex above line v = 30 and meeting trapezium at least once V marked correctly	B1 DB1 (2)
(d)	$30 = 1.5t_1 \Rightarrow t_1 = 20$ $30 = 1.25t_2 \Rightarrow t_2 = 24$ $\frac{1}{2}(20 + 28 + 24)V = 1500$ $V = \frac{750}{18} = 41.67$ $= \frac{125}{3}$ (oe) 0r 42 (or better)	M1 A1 A1 M1 A1 A1 (6) **15**

7. (a)	$\frac{(\mathbf{i} - 4\mathbf{j}) - (4\mathbf{i} - 8\mathbf{j})}{0.5}$;$(\pm 6\mathbf{i} \pm 8\mathbf{j})$ $\sqrt{(\pm 6)^2 + (\pm 8)^2} = 10$	M1 A1 M1 A1 (4)
(b)	$\mathbf{r} = (4\mathbf{i} - 8\mathbf{j}) + t(-6\mathbf{i} + 8\mathbf{j})$ $=(4\mathbf{i} - 8\mathbf{j}) - 6t\mathbf{i} + 8t\mathbf{j}$ $=(4 - 6t)\mathbf{i} + (8t - 8)\mathbf{j}$ *	M1 A1 (2)
(c)	At 10 am, $\mathbf{r} = -2\mathbf{i}$ At 10.30 am, $\mathbf{r} = -5\mathbf{i} + 4\mathbf{j}$ $\mathbf{l} = k\mathbf{i},\ k < -2$ $k = -5 - 4 = -9$ $\mathbf{l} = -9\mathbf{i}$	M1 A1 A1 DM1 A1 (5) **11**

Question Number	Scheme	Marks
8. **(a)**	$t = 0$ gives $\mathbf{v} = \mathbf{i} - 3\mathbf{j}$ speed $= \sqrt{1^2 + (-3)^2}$ $= \sqrt{10} = 3.2$ or better	B1 M1 A1 **(3)**
(b)	$t = 2$ gives $\mathbf{v} = (-3\mathbf{i} + 3\mathbf{j})$ Bearing is 315°	M1 A1 **(2)**
(c)(i) **(ii)**	$1 - 2t = 0 \Rightarrow t = 0.5$ $-(3t - 3) = -3(1 - 2t)$ Solving for t t = 2/3, 0.67 or better	M1 A1 M1 A1 **DM**1 A1 **(6)** **[11]**

Examiner reports

Question 1

A good starter question enabling most candidates to obtain marks. A significant number of candidates gave an answer of -16 in part (a) rather than giving the magnitude of the impulse and lost a mark.

In part (b) 16 was a common incorrect answer resulting from an incorrect direction of motion for particle *B* i.e. 4 x 5 – *m* x 3 = 4 x 1 – *m* x 2. A few candidates seemed unconcerned with a negative mass obtained from using (+ *m* x 3) on the L.H.S. and there were also a few instances of candidates quoting and using the "formula" $m_1u_1 + m_1v_1 = m_2u_2 + m_2v_2$. It was rare to see correct solutions using Impulse and many included g in their Impulse-Momentum equation.

Question 2

This question produced very many correct responses. In part (a) most candidates were able to apply the conservation of momentum principle with few problems, with many candidates achieving all four marks. As usual a significant number, maybe fewer than in previous years, made sign errors, with the occasional candidate missing the odd '*m*'s or '*u*'s. Very few put '*g*'s into the equation while others had difficulty in manipulating the fractions Arithmetic errors in working out the value of *k* were not uncommon and negative values obtained for *k* seldom alerted the candidates to a possible error in their work. In the second part, the majority of candidates chose to use the change in momentum of *P* with many correct answers being obtained. However there were the inevitable errors with signs, more than in part (a), with too many candidates thinking that a negative answer was acceptable, misunderstanding the meaning of 'magnitude'.

Question 3

Part (a)
Most candidates answered this correctly, usually taking moments about *C*, although a small minority took moments about *A* or *D* having first ascertained the normal reaction at *C*.
Part (b)
Candidates were less successful with this part. The successful answers usually took moments about *D* which they placed to the left of the centre of mass and called the distance *AD* '*x*'. This method obviated the need to find the normal reaction at *D*. Among those others who were also successful, the majority took moments about *A* having ascertained the normal reaction at *D* and again calling *AD* '*x*'. Some candidates created three unknowns: *AD*, *DC* and *DB*; these candidates were rarely successful in their answers, succumbing to the difficulty of unravelling a complexity of their own making. Other candidates failed for various reasons: some for incorrectly calculating the normal because they missed out the mass of the rod or one of the other masses, more usually the former, others because when they took moments about *D* they failed to take account of the mass of the rod, more usually, or one of the other masses. Some candidates were unsuccessful because they placed *D* on the right of the centre of mass and then ran into problems using (7.5 - *x*) rather than (*x* - 7.5).

Question 4

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 5

Most candidates were able to produce two valid equations in part (a), with the majority using one moments and a vertical resolution. Occasionally g was omitted from the weight terms and, more rarely, a reaction was equated to the sum of moments; this led to a dimensionally incorrect equation and a significant loss of marks. A relatively small number of candidates misinterpreted the given information and included the supports in the wrong positions on the rod (often 1 m from the ends) while others failed to realise there were two reaction forces.

It was possible to find the value of the reaction directly by taking moments about R, but many found two equations and solved them simultaneously to find the reaction and then used it to find the value of M. A common error was to give the answer for the reaction as 313.6 which represents unjustifiable accuracy after using $g = 9.8$ (314, 310 or $32g$ were all acceptable).

Many comments in part (b) related to the concentration of mass at a point, or the weight acting through the point given; these achieved the mark. Some comments were irrelevant and just referred to, for example, weight acting downwards, or 'enabling moments to be taken'.

Question 6

A large number of entirely (or almost) correct solutions were seen to this question. Most candidates drew their velocity-time graphs correctly and included appropriate annotations, with the most common error being that the lines drawn did not cross. This did not deny candidates access to full marks in the rest of the question though and many went on to solve the problem correctly. Most realised that they needed to equate the expressions for area under the graph to 800 for both P and Q. Attempts to use constant acceleration formulae over the whole distance were occasionally seen and scored no marks although a few used this approach in a valid way for the separate parts of the motion. Most commonly, a combination of rectangles and triangles were used to represent area rather than the area of a trapezium which made the subsequent algebra more difficult, and there were occasional errors seen in simplification. A relatively common error was to calculate a correct time for Q ($t = 30$) but to misinterpret this as the time when they both came to rest leading to errors in the motion of P.

Question 7

Apart from the final two available marks, this vector question was generally well answered. In part (a) most candidates could derive the relevant velocity from the given position vectors and time. However, some failed to realise that 'speed' required evaluation of the magnitude of their vector. In the second part the required expression for the general position vector was given, and so it was essential that the derivation was clear and entirely correct, including "$\mathbf{r} =$ ". An incorrect velocity vector from part (a) correctly used here earned one of the two available marks. However, if the working was not consistent with that in part (a), both marks were lost unless there was clear evidence of the velocity being re-calculated. In part (c) many candidates substituted the relevant values of t (1 and 1.5) into the given expression to find the position vectors at these times. However, only a minority used these properly to solve the problem. Some realised that the **j**-component of the position vector of L was zero, but deduced that the **i**-component was –8**i** or –7**i** rather than the correct value –9**i**. A clear diagram would have helped many to fully appreciate the situation.

Question 8

In part (a) the vast majority obtained **i** – 3**j**, and only a few of these forgot to go on and find the speed. In the second part almost all tried to substitute $t = 2$, and almost all of these obtained -3i + 3j; there were, however, many errors in finding the bearing, with 225° being the most common incorrect answer. In part (c) (i) most candidates seemed to realise that something had to be equated to zero; approximately half of them took it to be the **i**-component of v, leading correctly to $t = \frac{1}{2}$. Of the remainder, some thought that the **j**-component should be zero, while a substantial number equated both components in turn to zero, obtaining two values for t. It was part (c) (ii) that proved to be a good discriminator. Many just gave up at this point, while some tried equating the **i**-component to –1 and the **j**-component to –3, again obtaining two values for t. Of those who knew how to proceed, the k-method seemed less error-prone than the 'going straight to the ratio' method, with perhaps less risk of ending up with the ratio the wrong way round. It was surprising to see how many found the value of k first, then substituted it back into one of their equations rather than just eliminating it immediately.

Statistics for M1 Practice Paper Silver Level S1

					Mean score for students achieving grade:						
Original paper	Qu	Mean score	Max score	Mean %	ALL	A	B	C	D	E	U
0801	**1**	5.04	6	84	5.04	5.62	5.21	5.06	4.32	3.89	2.82
1006	**2**	5.26	7	75	5.26	6.42	5.85	5.30	4.56	3.65	1.95
0706	**3**	6.74	9	75	6.74	8.57	7.87	6.92	5.72	4.22	1.89
0806	**4**	6.03	8	75	6.03	7.43	6.64	5.93	5.18	4.30	2.59
1106	**5**	7.34	11	67	7.34	9.53	8.33	7.13	5.62	4.07	1.79
1006	**6**	8.19	12	68	8.19	10.67	8.82	7.43	6.20	5.03	3.43
1301	**7**	7.43	11	68	7.43	9.08	7.54	6.16	4.91	3.43	2.08
1306	**8**	6.48	11	59	6.48	8.73	6.87	5.89	5.05	4.18	2.66
		52.51	**75**	**70**	**52.51**	**66.05**	**57.13**	**49.82**	**41.56**	**32.77**	**19.21**