Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Bronze Level B1

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
75	70	64	54	44	36

1. Particle P has mass 3 kg and particle Q has mass m kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision, the speed of P is 4 m s^{-1} and the speed of Q is 3 m s^{-1}. In the collision the direction of motion of P is unchanged and the direction of motion of Q is reversed. Immediately after the collision, the speed of P is 1 m s^{-1} and the speed of Q is 1.5 m s^{-1}.

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

(3)

(*b*) Find the value of m.

(3)

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2. An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of 8 m s^{-1}. This speed is then maintained for T seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 s.

(*a*) Sketch a speed-time graph to illustrate the motion of the athlete.

(3)

(*b*) Calculate the value of T.

(5)

3.

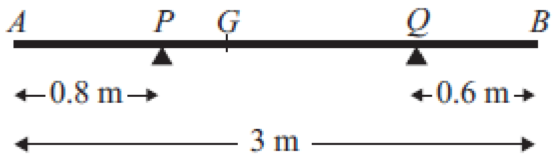

Figure 1

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)

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4. A lifeboat slides down a straight ramp inclined at an angle of 15° to the horizontal. The lifeboat has mass 800 kg and the length of the ramp is 50 m. The lifeboat is released from rest at the top of the ramp and is moving with a speed of 12.6 m s^{-1} when it reaches the end of the ramp. By modelling the lifeboat as a particle and the ramp as a rough inclined plane, find the coefficient of friction between the lifeboat and the ramp.

(9)

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5. A car is moving on a straight horizontal road. At time $t = 0$, the car is moving with speed 20 m s^{-1} and is at the point *A*. The car maintains the speed of 20 m s^{-1} for 25 s. The car then moves with constant deceleration 0.4 m s^{-2}, reducing its speed from 20 m s^{-1} to 8 m s^{-1}. The car then moves with constant speed 8 m s^{-1} for 60 s. The car then moves with constant acceleration until it is moving with speed 20 m s^{-1} at the point *B*.

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

(3)

(*b*) Find the time for which the car is decelerating.

(2)

Given that the distance from *A* to *B* is 1960 m,

(*c*) find the time taken for the car to move from *A* to *B*.

(8)

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6. A car accelerates uniformly from rest for 20 seconds. It moves at constant speed v m s^{-1} for the next 40 seconds and then decelerates uniformly for 10 seconds until it comes to rest.

(*a*) For the motion of the car, sketch

(i) a speed-time graph,

(ii) an acceleration-time graph.

(6)

Given that the total distance moved by the car is 880 m,

(*b*) find the value of v.

(4)

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

A ship S is moving with constant velocity $(3\mathbf{i} + 3\mathbf{j})$ km h^{-1}. At time $t = 0$, the position vector of S is $(-4\mathbf{i} + 2\mathbf{j})$ km.

(*a*) Find the position vector of S at time t hours.

(2)

A ship T is moving with constant velocity $(-2\mathbf{i} + n\mathbf{j})$ km h^{-1}. At time $t = 0$, the position vector of T is $(6\mathbf{i} + \mathbf{j})$ km. The two ships meet at the point P.

(*b*) Find the value of n.

(5)

(*c*) Find the distance OP.

(4)

8.

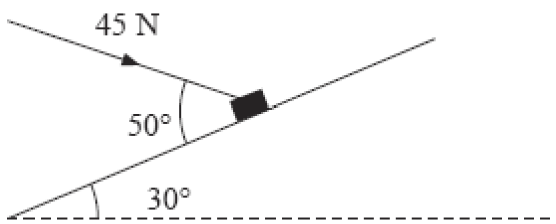


Figure 3

A package of mass 4 kg lies on a rough plane inclined at 30° to the horizontal. The package is held in equilibrium by a force of magnitude 45 N acting at an angle of 50° to the plane, as shown in Figure 3. The force is acting in a vertical plane through a line of greatest slope of the plane. The package is in equilibrium on the point of moving up the plane. The package is modelled as a particle. Find

(*a*) the magnitude of the normal reaction of the plane on the package,

(5)

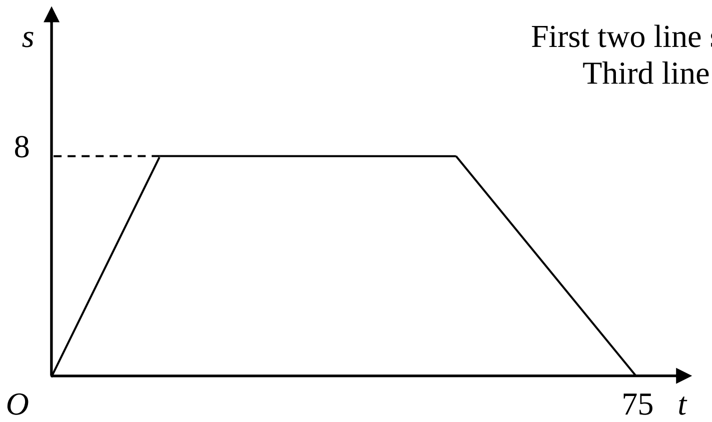
(*b*) the coefficient of friction between the plane and the package.

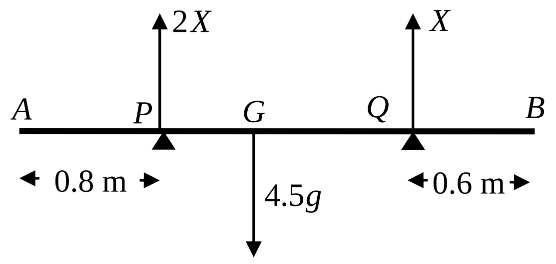
(6)

TOTAL FOR PAPER: 75 MARKS

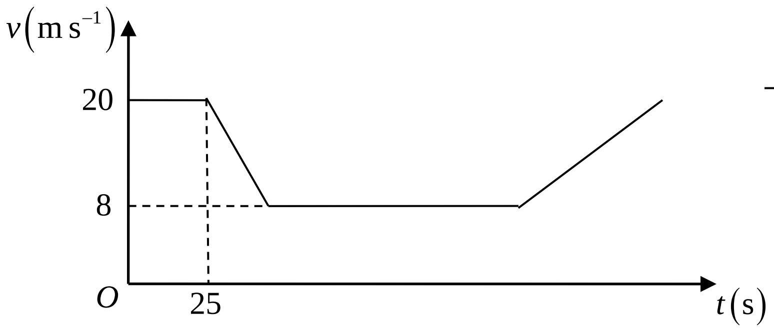
END

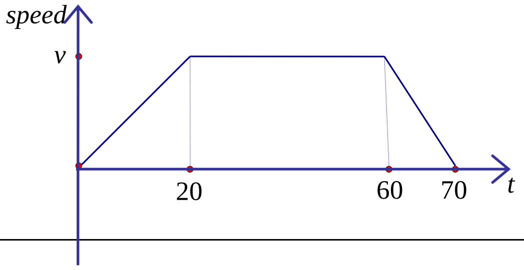
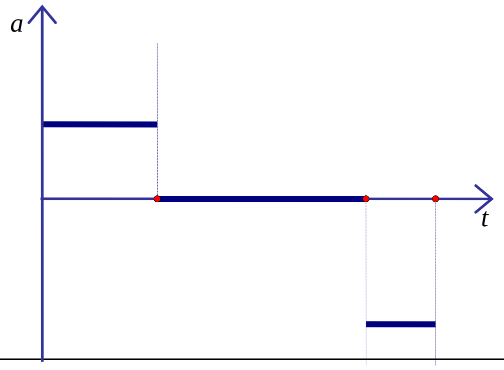
Question Number	Scheme	Marks
1.		
(a)	For P, $-I = 3(1-4)$	M1 A1
	$I = 9$ Ns	A1
		(3)
(b)	For Q, $9 = m(1.5 - -3)$	M1 A1
	$m = 2$	A1
	OR	
	$12 - 3m = 3 + 1.5m$	M1 A1
	$m = 2$	A1
		(3)
		[6]

Question Number	Scheme	Marks
Q2.	(a) 	
	First two line segments	B1
	Third line segment	B1
	8, 75	B1 (3)
	(b) $\frac{1}{2} \times 8 \times (T + 75) = 500$	M1 A2 (1,0)
	Solving to $T = 50$	DM1 A1 (5)
		[8]

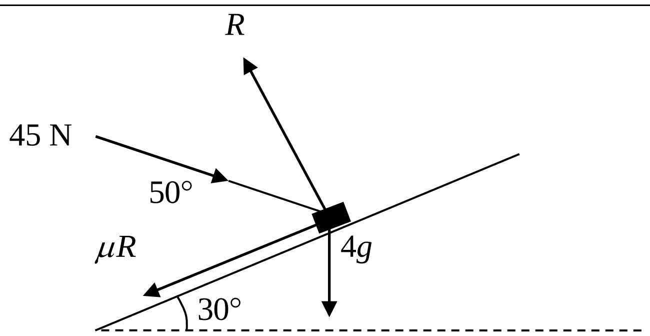
Question Number	Scheme	Marks
3.	 	
	(a) ↑ $2X + X = 4.5g$	M1 A1
	Leading to $X = \frac{3g}{2}$ or 14.7 or 15 (N)	A1 **(3)**
	(b) M(A) $4.5g \times AG = (2X) \times 0.8 + X \times 2.4$	M1 A2 **ft** (1,0)
	$AG = \frac{4}{3}$ (m), 1.3, 1.33,...	A1 **(4)**
		[7]

4.	$12.6^2 = 2a.50$ (Þ $a = 1.5876$)	M1 A1
	$800g\sin 15 - F = 800a$	M1 A1
	$R = 800g\cos 15$	M1 A1
	$F = mR$	B1
	$800g\sin 15 - m800g\cos 15 = 800 \text{ x } 1.5876$	M1
	m= 0.1, 0.10, 0.100	A1
		9

Question Number	Scheme	Marks
5.	(a)  20, 8, 25	B1 B1 B1 **(3)**
(b)	$v = u + at \Rightarrow 8 = 20 - 0.4t$ $t = 30\ (\text{s})$	M1 A1 **(2)**
(c)	1960 = (25 x 20) +(30 x 8) + (½ x 30 x 12) + (60 x 8) + 8 x t + ½ x t x 12	M1A3 **ft** (2 ,1, 0)
	1960 = 500 + 240 + 180 + 480 + 14t	DM1 A1
	T = 115 + 40 = 155	DM1 A1 **(8)** **[13]**

Question Number	Scheme		Marks
6. **(a)** **(i)**		1st section correct 2nd & 3rd sections correct Numbers and v marked correctly on the axes.	B1 B1 DB1
(ii)		1st section correct 2nd section correct 3rd section correct and no "extras" on the sketch	B1 B1 B1 (6)
(b)	$\frac{70+40}{2}\times v=880$ $v=880\times\frac{2}{110}=16$		M1 A1 DM1 A1 (4) **[10]**

Question Number	Scheme	Marks
7. (a)	Use of $\mathbf{r} = \mathbf{r}_0 + \mathbf{v}t$	M1
	$(-4\mathbf{i} + 2\mathbf{j}) + (3\mathbf{i} + 3\mathbf{j})t = (-4 + 3t)\mathbf{i} + (2 + 3t)\mathbf{j}$	A1
		(2)
(b)	$(6\mathbf{i} + \mathbf{j}) + (-2\mathbf{i} + n\mathbf{j})t = (6 - 2t)\mathbf{i} + (1 + nt)\mathbf{j}$	B1
	Position vectors identical $\Rightarrow -4 + 3t = 6 - 2t$ **AND** $5t = 10$,	M1
	Either equation	A1
	$2 + 3\times 2 = 1 + 2n$,	**DM1**
	$n = 3.5$	A1
		(5)
(c)	Position vector of P is $(-4+6)\mathbf{i} + (2+6)\mathbf{j} = 2\mathbf{i} + 8\mathbf{j}$	M1A1
	Distance OP $= \sqrt{2^2 + 8^2} = \sqrt{68} = 8.25$ (km)	M1A1
		(4)
		[11]

8. (*a*)			
	$R = 45\cos 40° + 4g\cos 30°$		M1 A2, 1, 0
	$R \approx 68$	accept 68.4	M1 A1 (5)
(*b*)	Use of $F = \mu R$		M1
	$F + 4g\sin 30 = 45\cos 50°$		M1 A2, 1, 0
	Leading to $\mu \approx 0.14$	accept 0.136	M1 A1(6)
			(11 marks)

Examiner reports

Question 1

This question was generally well answered. In part (a), almost all candidates quoted and used an appropriate formula for impulse in terms of difference of momenta. Since the magnitude of the impulse was asked for, a positive value was required for the final mark. If the impulse on *Q* rather than *P* was considered, to be eligible for a method mark it was necessary to find and substitute a value for m. The majority of candidates chose to use a 'conservation of linear momentum' equation in part (b). There were occasional sign, miscopying or arithmetical errors, but these were rare, and full marks were often achieved. Those who chose to use an impulse equation for the other particle generally did so successfully.

Question 2

In part (a) the speed-time graph was almost universally correct. Most candidates realised, in the second part, that the area under the graph was equal to the distance travelled and were able to calculate the correct area of 20 for the first part of the motion. Errors in the interpretation of *T* caused most of the problems in the calculations of the other areas. Comparatively few used an area of a trapezium which provided the neatest solution.

Question 3

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 4

Candidates seemed to like this question and there were many correct solutions. Most candidates found the acceleration successfully using *suvat* but some treated the whole question as a statics problem. Others omitted the weight component when resolving along the plane and a few used 30° instead of 15°. Occasionally sine and cosine were mixed up when resolving but for the most part the candidates produced convincing solutions.

Question 5

The graph was usually correct in part (a) but some candidates included an initial period of acceleration from rest or an extra constant speed section at the end whilst others missed out one of the required figures. The majority of candidate scored both marks in the second part but it was quite common to see a sign error (in the acceleration) leading to $t = –30$, with the minus sign being then conveniently dropped. Some candidates obtained $t = 30$ but then subtracted 25 and said it decelerated for 5 seconds, whilst others found the elapsed time at the end of the deceleration ($T = 55$) and forgot to subtract 30.

Methods attempted in part (c) were mostly correct with a variety of ways used to find the total area under the graph. A few treated the graph for the first 55s as a single trapezium. There was also some confusion as to whether it was the final time that was needed or the time for the final acceleration and several stopped, having calculated $t = 40$ or added 115 having calculated $T = 155$. Some used *suvat* equations for each section of the graph, usually successfully, but there were instances of a single equation being used for the whole time period!

Most candidates attempted to equate the area under the graph to 1960 (although there were a few who worked out the various sectional areas, and even added them together, but for whatever reason didn't then equate their sum to 1960). There were many ways of slicing up the area, and examiners had to be careful in counting the errors; since an incorrect answer to part (b) could still produce a correct answer in part (c), examiners took particular care in marking this. Most area errors resulted from wrong timings - for instance a mistake in part (b) or subtracting the 30 in part (b) from 60 so that it travelled at constant speed for only 30s in the third section or from missing out portions of the area or using the wrong formula for the area of a trapezium: it was sometimes impossible to tell which error it was.

Question 6

The vast majority of candidates achieved full marks for the speed-time graph in part (a) and for equating the area under the graph to the given distance in order to find v, in part (c). Occasionally 'v' was left off the axis, or '40, 50' labelled instead of '60, 70' which also led to errors in part (c). The acceleration-time graph in the second part provided a greater challenge and some non-horizontal lines were seen. Those who had a graph with the correct basic shape were penalised if they included vertical lines on their sketch, although dotted lines were acceptable.

Question 7

This was a straightforward vector question with the vast majority of candidates who attempted it scoring full marks. Those who were unsure what to do usually were able to score the first three marks for the position vectors of S and T. In part (b) a few were confused about which components to equate and lost marks if they didn't equate both and in the final part some obtained the correct position vector for P but then forgot to calculate the appropriate distance.

Question 8

It was good to see so many fully correct solutions to this question which was best solved by resolving parallel and perpendicular to the plane. Only the weakest candidates failed to include all the relevant forces. Those candidates who attempted vertical and horizontal resolution often fell victim to inaccuracies in angles or more costly, to missing forces. Since g = 9.8 had been used, the final mark in part (a) was often lost for an answer of 68.42. Virtually all tried to use F = μR appropriately in part (b) although occasionally F was acting in the wrong direction. Other errors in both parts included incorrect signs, confusion over which angles to use and sine/cosine applied the wrong way round.

Statistics for M1 Practice Paper Bronze Level B1

					Mean score for students achieving grade:						
Original paper	**Qu**	**Mean score**	**Max score**	**Mean %**	**ALL**	**A**	**B**	**C**	**D**	**E**	**U**
1306	**1**	5.32	6	89	5.32	5.81	5.63	5.48	5.25	4.91	3.58
1001	**2**	6.87	8	86	6.87	7.54	7.04	6.45	5.87	5.28	4.21
1206	**3**	5.48	7	78	5.48	6.65	6.24	5.63	4.77	3.62	1.63
1301	**4**	7.48	9	83	7.48	8.52	7.68	7.04	6.31	4.93	3.35
1206	**5**	10.92	13	84	10.92	12.43	11.74	10.97	10.05	8.91	6.44
1101	**6**	8.56	10	86	8.56	9.37	8.73	8.08	7.64	6.89	4.85
1306R	**7**	9.01	11	82	9.01	10.43	9.82	8.12	6.18	5.75	3.74
0806	**8**	7.75	11	70	7.75	10.11	9.01	7.68	5.93	4.42	1.91
		61.39	**75**	**81**	**61.39**	**70.86**	**65.89**	**59.45**	**52.00**	**44.71**	**29.71**