Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Gold Level G3

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 6 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
62	54	46	37	29	22

1. At time $t = 0$, a particle is projected vertically upwards with speed u m s^{-1} from a point 10 m above the ground. At time T seconds, the particle hits the ground with speed 17.5 m s^{-1}. Find

(*a*) the value of u,

(3)

(*b*) the value of T.

(4)

May 2008

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2. A particle P of mass 2 kg is moving under the action of a constant force $\mathbf{F}$ newtons. The velocity of P is $(2\mathbf{i} - 5\mathbf{j})$ m s^{-1} at time $t = 0$, and $(7\mathbf{i} + 10\mathbf{j})$ m s^{-1} at time $t = 5$ s.

Find

(*a*) the speed of P at $t = 0$,

(2)

(*b*) the vector $\mathbf{F}$ in the form $a\mathbf{i} + b\mathbf{j}$,

(5)

(*c*) the value of t when P is moving parallel to $\mathbf{i}$.

(4)

January 2011

3.

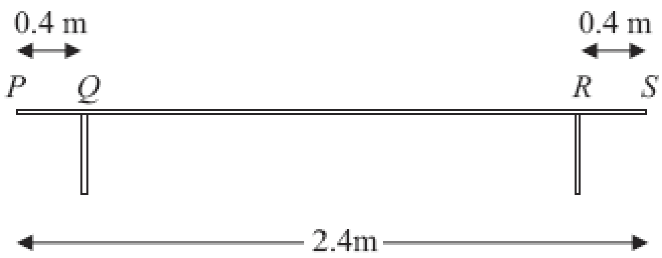


Figure 1

A bench consists of a plank which is resting in a horizontal position on two thin vertical legs. The plank is modelled as a uniform rod PS of length 2.4 m and mass 20 kg. The legs at Q and R are 0.4 m from each end of the plank, as shown in Figure 1.

Two pupils, Arthur and Beatrice, sit on the plank. Arthur has mass 60 kg and sits at the middle of the plank and Beatrice has mass 40 kg and sits at the end P. The plank remains horizontal and in equilibrium. By modelling the pupils as particles, find

(*a*) the magnitude of the normal reaction between the plank and the leg at Q and the magnitude of the normal reaction between the plank and the leg at R.

(7)

Beatrice stays sitting at P but Arthur now moves and sits on the plank at the point X. Given that the plank remains horizontal and in equilibrium, and that the magnitude of the normal reaction between the plank and the leg at Q is now twice the magnitude of the normal reaction between the plank and the leg at R,

(*b*) find the distance QX.

(6)

January 2009

4.

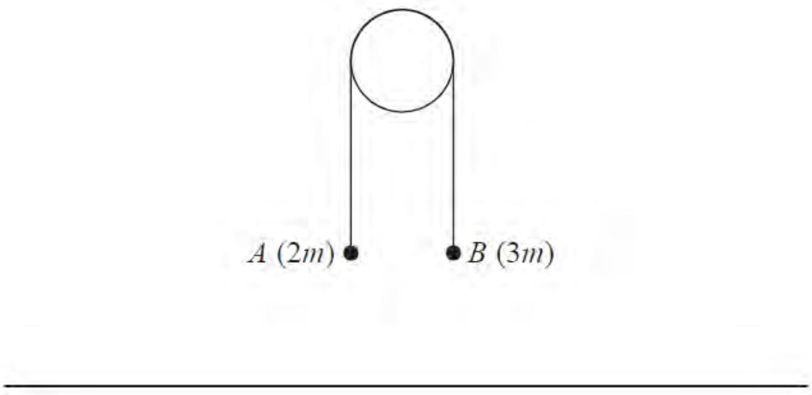


Figure 2

Two particles A and B have masses $2m$ and $3m$ respectively. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut. The hanging parts of the string are vertical and A and B are above a horizontal plane, as shown in Figure 2. The system is released from rest.

(a) Show that the tension in the string immediately after the particles are released is $\frac{12}{5}mg$.

(6)

After descending 1.5 m, B strikes the plane and is immediately brought to rest. In the subsequent motion, A does not reach the pulley.

(b) Find the distance travelled by A between the instant when B strikes the plane and the instant when the string next becomes taut.

(6)

Given that $m = 0.5$ kg,

(c) find the magnitude of the impulse on B due to the impact with the plane.

(2)

June 2014 (R)

5.

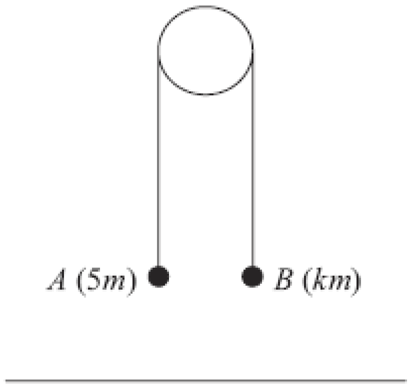


Figure 3

Two particles A and B have masses $5m$ and km respectively, where $k < 5$. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal plane, as shown in Figure 3. The system is released from rest. After release, A descends with acceleration $\frac{1}{4}g$.

(*a*) Show that the tension in the string as A descends is $\frac{15}{4}mg$.

(3)

(*b*) Find the value of k.

(3)

(*c*) State how you have used the information that the pulley is smooth.

(1)

After descending for 1.2 s, the particle A reaches the plane. It is immediately brought to rest by the impact with the plane. The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.

(*d*) Find the greatest height reached by B above the plane.

(7)

January 2010

6.

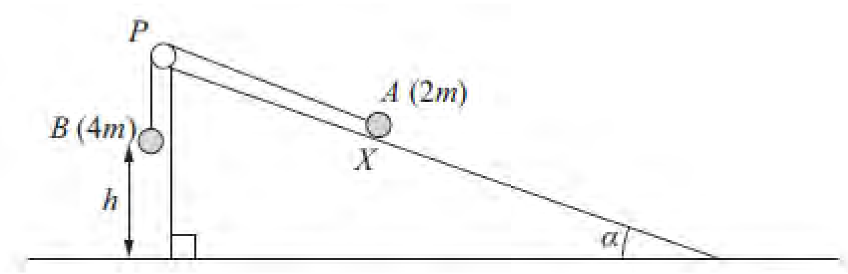


Figure 4

Figure 4 shows two particles A and B, of mass $2m$ and $4m$ respectively, connected by a light inextensible string. Initially A is held at rest on a rough inclined plane which is fixed to horizontal ground. The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between A and the plane is $\frac{1}{4}$. The string passes over a small smooth pulley P which is fixed at the top of the plane. The part of the string from A to P is parallel to a line of greatest slope of the plane and B hangs vertically below P. The system is released from rest with the string taut, with A at the point X and with B at a height h above the ground.

For the motion until B hits the ground,

(*a*) give a reason why the magnitudes of the accelerations of the two particles are the same,

(1)

(*b*) write down an equation of motion for each particle,

(4)

(*c*) find the acceleration of each particle.

(5)

Particle B does not rebound when it hits the ground and A continues moving up the plane towards P. Given that A comes to rest at the point Y, without reaching P,

(*d*) find the distance XY in terms of h.

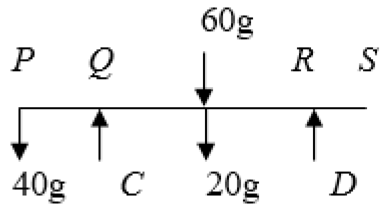
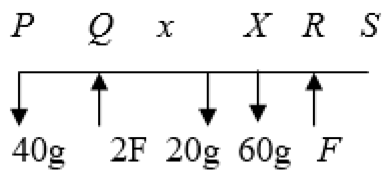
(6)

January 2013

TOTAL FOR PAPER: 75 MARKS

END

Question number	Scheme	Marks
1 (a)	$v^2 = u^2 + 2as \quad \Rightarrow \quad 17.5^2 = u^2 + 2 \times 9.8 \times 10$	M1 A1
	Leading to $u = 10.5$	A1
		(3)
(b)	$v = u + at \quad \Rightarrow \quad 17.5 = -10.5 + 9.8T$	M1 A1 ft.
	$T = 2\frac{6}{7}$ (s)	M1 A1
		(4)
		[7]
2 (a)	speed $= \sqrt{2^2 + (-5)^2}$	M1
	$= \sqrt{29} = 5.4$ or better	A1
		(2)
(b)	$((7\mathrm{i} + 10\mathrm{j}) - (2\mathrm{i} - 5\mathrm{j}))/5$	M1 A1
	$= (5\mathbf{i} + 15\mathbf{j})/5 = \mathbf{i} + 3\mathbf{j}$	A1
	$\mathbf{F} = m\mathbf{a} = 2(\mathbf{i} + 3\mathbf{j}) = 2\mathbf{i} + 6\mathbf{j}$	DM1 A1ft
		(5)
(c)	$\mathbf{v} = \mathbf{u} + \mathbf{a}t = (2\mathbf{i} - 5\mathbf{j}) + (\mathbf{i} + 3\mathbf{j})t$	M1
	$(-5 + 3t)\mathrm{j}$	A1
	Parallel to i $\Rightarrow -5 + 3t = 0$	M1
	$t = 5/3$	A1
		(4)
		[11]

Question number	Scheme	Marks
3 (a)		
	$C + D = 120g$	M1 A1
	$M(Q)$, $80g.0.8 - 40g.0.4 = D.1.6$	M1 A1
	solving	
	$C = 90g; D = 30g$	M1
		A1 A1
		(7)
(b)		
	$2F + F = 40g + 20g + 60g$	M1 A1
	$M(Q)$, $60gx + 20g.0.8 = 40g.0.4 + F.1.6$	M1 A1
	solving	M1
	$QX = x = \frac{16}{15}$ m $= 1.07$m	A1
		(6)
		[13]

Question number	Scheme	Marks
4 (a)	$3mg - T = 3ma$	M1A1
	$T - 2mg = 2ma$	M1A1
	$T = 2mg + 2\left(mg - \frac{T}{3}\right)$	**DM**1
	$T = \frac{12}{5}mg$ ***Given Answer***	A1
		(6)
(b)	$a = \frac{g}{5}$	B1
	At time of impact $v^2 = u^2 + 2as = 2\times\frac{g}{5}\times 1.5 = 0.6g$	M1A1
	Vertical motion under gravity $0 = 0.6g - 2gs$	M1
	$s = 0.3\,(\text{m})$	
	Total distance $2\times 0.3 = 0.6$ (m)	**DM**1A1
		(6)
(c)	Impulse = $3m(v-u) = -3mu$	M1
	Magnitude = $3m\sqrt{0.6g} = 3.6$ (Ns) (3.64)	A1
		(2)
		[14]

Question number	Scheme	Marks
5 (a)	N2L A: $5mg - T = 5m \times \frac{1}{4}g$	M1 A1
	$T = \frac{15}{4}mg$ ∗ cso	A1
		(3)
(b)	N2L B: $T - kmg = km \times \frac{1}{4}g$	M1 A1
	$k = 3$	A1
		(3)
(c)	The tensions in the two parts of the string are the same	B1
		(1)
(d)	Distance of A above ground $s_1 = \frac{1}{2} \times \frac{1}{4}g \times 1.2^2 = 0.18g \; (\approx 1.764)$	M1 A1
	Speed on reaching ground $v = \frac{1}{4}g \times 1.2 = 0.3g \; (\approx 2.94)$	M1 A1
	For B under gravity $(0.3g)^2 = 2gs_2 \;\; \Rightarrow \;\; s_2 = \frac{(0.3)^2}{2}g \; (\approx 0.441)$	M1 A1
	$S = 2s_1 + s_2 = 3.969 \approx 4.0$ (m)	A1
		(7)
		[14]

Question number	Scheme	Marks
6 (a)	Inextensible string	B1
		(1)
(b)	$4mg - T = 4ma$	M1 A1
	$T - 2mg\sin\alpha - F = 2ma$	M1 A1
		(4)
(c)	$F = 0.25R$	**B1**
	$R = 2mg\cos\alpha$	B1
	$\cos\alpha = 0.8$ or $\sin\alpha = 0.6$	B1
	Eliminating R, F and T	M1
	$a = 0.4g = 3.92$	A1
		(5)
(d)	$v^2 = 2 \text{ x } 0.4gh$	M1
	$-2mg\sin\alpha - F = 2ma'$	M1
	$a' = -0.8g$	A1
	$0^2 = 0.8gh - 2\text{x } 0.8g \text{ x } s$	M1
	$s = 0.5h$	A1
	$XY = 0.5h + h = 1.5h$	A1
		(6)
		[16]

Examiner reports

Question 1

There were various approaches that could be applied successfully to answer this question. Those who fully understood the implications of projecting from above ground level could achieve full marks by the most direct method although sign errors were not uncommon. Another popular approach was to split the motion into two stages (to and from the highest point) in both part (a) to find the initial velocity, and in part (b) to find the whole time. Although this required more working, there tended to be fewer sign errors. Premature approximation occasionally led to inaccuracy in the final answer. The weakest candidates sometimes only considered motion to or from the highest point. It should be noted that the rubric requires $g = 9.8$ to be used and not 9.81, which was penalised.

Question 2

In part (a) almost all candidates found the magnitude of the velocity to give the speed correctly. Most derived the acceleration, in the second part, by subtracting the velocities and dividing by the time appropriately (often by setting up a $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ equation first); however, a significant minority continue to lack confidence in dealing with vectors and vector notation. Most realised they then had to multiply by the mass to find the force, but sometimes the answer given was the same as the acceleration. The final part proved to be a good discriminator. Some failed to set up an equation in terms of t for the velocity, using their acceleration and the initial velocity; various combinations of terms were often seen. Many realised the **j**-component had to be zero, but some equated the **i**-component to zero whilst others equated the two components. Nevertheless, there were a significant number of candidates who correctly deduced the answer, often with very little working.

Question 3

Part (a) was well answered with the majority of candidates realising that they had to take moments. A common and costly error was to omit the distance when taking the moment of one or both of the reaction forces. Some candidates took moments twice, usually about Q then about R but these tended to be less successful than those who took moments and resolved vertically. A few students missed off g's from their weight terms. In the second part, again the most productive method was to resolve vertically and use one moments equation. Those who opted to take moments twice had more algebraic manipulation to contend with, which at times was a problem. Poor diagrams often resulted in finding and using wrong distances.

Question 4

Part (a) was mostly well done although some omitted the m from the 'ma' term in their equations of motion which nonetheless still led to the given answer for T and examiners had to be alert to ensure that unwarranted marks weren't awarded.

The second part was only really successfully done by stronger students as again the algebra made it less accessible. Many used g not $0.2g$ and added 1.5 m instead of doubling their distance. Part (c), m was used in the impulse-momentum equation instead of $3m$ in the majority of cases.

Question 5

Part (a) was reasonably well done by the majority of students, with good use of the printed answer to correct sign errors etc. but there was less success in the second part, with omission of m and/or g from some terms. The mark in part (c) was very rarely scored and candidates should be aware that if they give a 'list' of answers they will not be awarded the mark, even if the correct answer appears in their list. The final part was a good discriminator and led to Q6 being the worst answered question on the paper. Consideration of two stages to the motion was required, with two distinct accelerations. Many completely omitted the motion under gravity and found the distance moved by A and either gave that as their answer or else just doubled it.

Question 6

The relevant modelling assumption that leads to the accelerations of both particles being the same is that the string is inextensible. If additional but not relevant reasons were stated in part (a), the mark for this was withheld. Not all candidates realised, in the second part, that 'equation of motion' refers to Newton's Second Law ('$F = ma$'), and some attempts at constant acceleration equations, or just combining forces, were seen. However, often these candidates proceeded to produce the correct equations in part (c) in order to calculate the acceleration; they were awarded marks retrospectively. Occasionally the weight was omitted from the resolution parallel to the plane but generally the friction term (including the normal reaction) was handled correctly. Correct trigonometric ratios were mostly identified and used appropriately. Generally the motion of connected particles seemed well understood although numerical slips, including sign errors when solving the simultaneous equations, sometimes led to a wrong final value for the acceleration. The final part proved to be much more of a challenge. Some realised that it was necessary to calculate the speed (in terms of h) when one of the particles hits the ground, but then made little further progress. Those who realised that a new acceleration was required by applying Newton's Second Law parallel to the plane, sometimes made a sign error or omitted the weight component. A significant minority did complete their solutions, but with numerical or algebraic errors which led to a wrong answer. Having obtained $v^2 = 0.8gh$ many then went on to write $v = 2.8h$ (or similar) producing an h^2 in the final equation. Nevertheless, there were some clear, entirely correct solutions seen.

Statistics for M1 Practice Paper Gold Level G3

Qu	Max score	Modal score	Mean %	Mean score for students achieving grade: ALL	A*	A	B	C	D	E	U
1	7		62	4.31		5.83	4.54	3.73	3.23	2.73	1.67
2	11		66	7.30	9.95	8.95	7.15	5.72	4.58	3.67	2.16
3	13		68	8.88		11.42	9.15	7.27	5.09	3.31	1.07
4	14		63	8.83	11.44	10.32	8.63	7.46	5.44	4.06	1.39
5	14		53	7.47		10.15	7.55	5.47	3.48	2.18	0.88
6	16	10	53	8.44	13.32	11.31	8.21	6.00	4.66	3.14	1.78
	75		**60.31**	**45.23**	**34.71**	**57.98**	**45.23**	**35.65**	**26.48**	**19.09**	**8.95**