Paper Reference(s)

6677

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Friday 22 May 2009 – Morning

Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Orange or 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 formulae 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 not gain full credit.

1. Three posts *P*, *Q* and *R*, are fixed in that order at the side of a straight horizontal road. The distance from *P* to *Q* is 45 m and the distance from *Q* to *R* is 120 m. A car is moving along the road with constant acceleration a m s^{-2}. The speed of the car, as it passes *P*, is u m s^{-1}. The car passes *Q* two seconds after passing *P*, and the car passes *R* four seconds after passing *Q*.

Find

(i) the value of u,

(ii) the value of a.

(7)

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2. A particle is acted upon by two forces $\mathbf{F}_1$ and $\mathbf{F}_2$, given by

$\mathbf{F}_1 = (\mathbf{i} - 3\mathbf{j})$ N,

$\mathbf{F}_2 = (p\mathbf{i} + 2p\mathbf{j})$ N, where p is a positive constant.

(*a*) Find the angle between $\mathbf{F}_2$ and $\mathbf{j}$.

(2)

The resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ is $\mathbf{R}$. Given that $\mathbf{R}$ is parallel to $\mathbf{i}$,

(*b*) find the value of p.

(4)

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3. Two particles *A* and *B* are moving on a smooth horizontal plane. The mass of *A* is $2m$ and the mass of *B* is m. The particles are moving along the same straight line but in opposite directions and they collide directly. Immediately before they collide the speed of *A* is $2u$ and the speed of *B* is $3u$. The magnitude of the impulse received by each particle in the collision is $\frac{7mu}{2}$.

Find

(*a*) the speed of *A* immediately after the collision,

(3)

(*b*) the speed of *B* immediately after the collision.

(3)

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4. 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)

5.

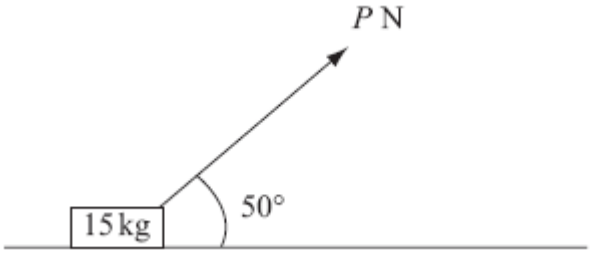

Figure 1

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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6. A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

(*a*) the acceleration of the car and trailer,

(3)

(*b*) the magnitude of the tension in the towbar.

(3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

(*c*) find the value of F.

(7)

7.

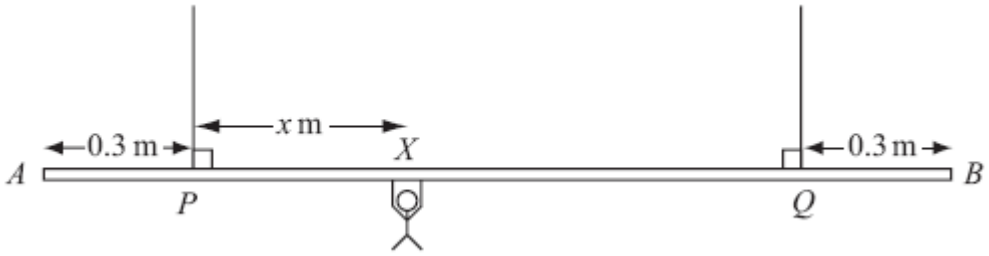

Figure 2

A beam AB is supported by two vertical ropes, which are attached to the beam at points P and Q, where $AP = 0.3$ m and $BQ = 0.3$ m. The beam is modelled as a uniform rod, of length 2 m and mass 20 kg. The ropes are modelled as light inextensible strings. A gymnast of mass 50 kg hangs on the beam between P and Q. The gymnast is modelled as a particle attached to the beam at the point X, where $PX = x$ m, $0 < x < 1.4$ as shown in Figure 2. The beam rests in equilibrium in a horizontal position.

(a) Show that the tension in the rope attached to the beam at P is $(588 – 350x)$ N.

(3)

(b) Find, in terms of x, the tension in the rope attached to the beam at Q.

(3)

(c) Hence find, justifying your answer carefully, the range of values of the tension which could occur in each rope.

(3)

Given that the tension in the rope attached at Q is three times the tension in the rope attached at P,

(d) find the value of x.

(3)

8. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively.*]

A hiker H is walking with constant velocity $(1.2\mathbf{i} - 0.9\mathbf{j})$ m s^{-1}.

(a) Find the speed of H.

(2)

Figure 3

A horizontal field $OABC$ is rectangular with OA due east and OC due north, as shown in Figure 3. At twelve noon hiker H is at the point Y with position vector $100\mathbf{j}$ m, relative to the fixed origin O.

(b) Write down the position vector of H at time t seconds after noon.

(2)

At noon, another hiker K is at the point with position vector $(9\mathbf{i} + 46\mathbf{j})$ m. Hiker K is moving with constant velocity $(0.75\mathbf{i} + 1.8\mathbf{j})$ m s^{-1}.

(c) Show that, at time t seconds after noon,

$$\overrightarrow{HK} = [(9 - 0.45t)\mathbf{i} + (2.7t - 54)\mathbf{j}] \text{ metres.}$$

(4)

Hence,

(d) show that the two hikers meet and find the position vector of the point where they meet.

(5)

TOTAL FOR PAPER: 75 MARKS

END

Question Number	Scheme	Marks
1.	$45 = 2u + \frac{1}{2}a2^2 \Rightarrow 45 = 2u + 2a$ $165 = 6u + \frac{1}{2}a6^2 \Rightarrow 165 = 6u + 18a$ eliminating either u or a $u = 20$ and $a = 2.5$	M1 A1 M1 A1 M1 A1 A1 **(7 marks)**
2. (a)	$\tan\theta = \frac{p}{2p} \Rightarrow \theta = 26.6°$	M1 A1 (2)
(b)	$\mathbf{R} = (\mathbf{i} - 3\mathbf{j}) + (p\mathbf{i} + 2p\mathbf{j}) = (1 + p)\mathbf{i} + (-3 + 2p)\mathbf{j}$ $\mathbf{R}$ is parallel to $\mathbf{i} \Rightarrow (-3 + 2p) = 0$ $\Rightarrow p = \frac{3}{2}$	M1 A1 DM1 A1 (4) **(6 marks)**
3. (a)	For A: $-\frac{7mu}{2} = 2m(v_A - 2u)$ $v_A = \frac{u}{4}$	M1 A1 A1 (3)
(b)	For B: $\frac{7mu}{2} = m(v_B - -3u)$ $v_B = \frac{u}{2}$	M1 A1 A1 (3) **(6 marks)**
4.	$0.5g\sin\theta - F = 0.5a$ $F = \frac{1}{3}R$ seen $R = 0.5g\cos\theta$ 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 $a = \frac{3g}{5}$ or $5.88\ \text{m s}^{-2}$ or $5.9\ \text{m s}^{-2}$	M1 A1 A1 B1 M1 A1 B1 DM1 A1 **[9]**
		(9 marks)

Question Number	Scheme	Marks
5.	$F = P\cos 50^o$	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)**
6. (a)	For whole system: $1200 - 400 - 200 = 1000a$	M1 A1
	$a = 0.6$ m s^{-2}	A1 (3)
(b)	For trailer: $T - 200 = 200$ x 0.6	M1 A1 **ft**
	$T = 320$ N	A1
	OR: For car: $1200 - 400 - T = 800$ x 0.6	**OR**: M1 A1 **ft**
	$T = 320$ N	A1 (3)
(c)	For trailer: $200 + 100 = 200f$ or $-200f$	M1 A1
	$f = 1.5$ m s^{-2} (-1.5)	A1
	For car: $400 + F - 100 = 800f$ or $-800f$	M1 A2
	$F = 900$	A1 (7)
	(N.B. For both: $400 + 200 + F = 1000f$)	**(13 marks)**

Question Number		Scheme	Marks
7.	(a)	$M(Q),\quad 50g(1.4-x)+20g \text{ x } 0.7 = T_P \text{ x } 1.4$	M1 A1
		$T_P = 588 - 350x$ Printed answer	A1 (3)
	(b)	$M(P),\quad 50gx + 20g \text{ x } 0.7 = T_Q \text{ x } 1.4$ or $R(\uparrow),\ T_P + T_Q = 70g$	M1 A1
		$T_Q = 98 + 350x$	A1 (3)
	(c)	Since $0 < x < 1.4$,	M1
		$98 < T_P < 588$ and $98 < T_Q < 588$	A1 A1 (3)
	(d)	$98 + 350x = 3\,(588 - 350x)$	M1
		$x = 1.19$	M1 A1 (3)
			(12 marks)
8.	(a)	$\lvert\mathbf{v}\rvert = \sqrt{1.2^2 + (-0.9)^2} = 1.5 \text{ m s}^{-1}$	M1 A1 (2)
	(b)	$(\mathbf{r}_H =) 100\mathbf{j} + t(1.2\mathbf{i} - 0.9\mathbf{j})$ m	M1 A1 (2)
	(c)	$(\mathbf{r}_K =) 9\mathbf{i} + 46\mathbf{j} + t(0.75\mathbf{i} + 1.8\mathbf{j})$ m	M1 A1
		$\overrightarrow{HK} = \mathbf{r}_K - \mathbf{r}_H = (9 - 0.45t)\mathbf{i} + (2.7t - 54)\mathbf{j}$ m **Printed Answer**	M1 A1 (4)
	(d)	Meet when $\overrightarrow{HK} = \mathbf{0}$	
		$(9 - 0.45t) = 0$ and $(2.7t - 54) = 0$	M1 A1
		$t = 20$ from both equations	A1
		$\mathbf{r}_K = \mathbf{r}_H = (24\mathbf{i} + 82\mathbf{j})$ m	M1 A1 **cso** (5)
			(13 marks)