OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2638

Mechanics 2

Tuesday **17 JUNE 2003** Afternoon 1 hour 20 minutes

Additional materials:
Answer booklet
Graph paper
List of Formulae (MF8)

TIME 1 hour 20 minutes

INSTRUCTIONS TO CANDIDATES

- Write your Name, Centre Number and Candidate Number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- Where a numerical value for the acceleration due to gravity is needed, use $9.8\,\mathrm{m\,s^{-2}}$.
- You are permitted to use a graphic calculator in this paper.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 60.
- Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.
- **You are reminded of the need for clear presentation in your answers.**

This question paper consists of 4 printed pages.

Registered Charity Number: 1066969

[Turn over

1 A car has a mass of 1000 kg and is moving horizontally at $8\,\text{m s}^{-1}$. The forward force is 3800 N and the car is accelerating at $3\,\text{m s}^{-2}$. Calculate

(i) the total resistance to the car's motion, [2]

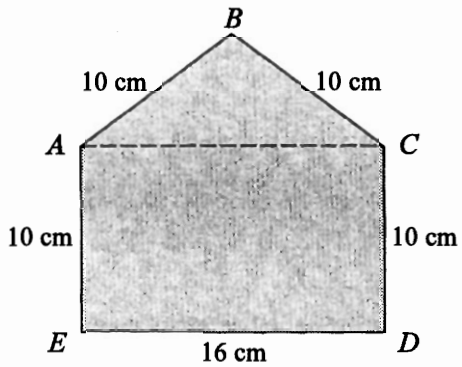
(ii) the power of the engine. [2]

2 A stone is projected from the top of a vertical cliff 100 m above the sea. The speed of projection is $30\,\text{m s}^{-1}$ and the direction makes an angle of 25° above the horizontal. Air resistance is to be ignored.

(i) Calculate the time that the stone takes to hit the sea. [4]

(ii) Find how far from the foot of the cliff the stone hits the sea. [2]

3



A uniform lamina consists of a rectangle and an isosceles triangle, as shown in the diagram. Each side of the lamina is of length 10 cm, except for DE which is 16 cm.

(i) Show that the distance of the centre of mass of the lamina from B is 9.38 cm, correct to 3 significant figures. [3]

(ii) The lamina is freely suspended from A. Calculate the angle that AC makes with the vertical. [2]

(iii) The mass of the lamina is 1.3 kg. A particle of mass m kg is attached to the lamina at B. When freely suspended from A, the lamina is now in equilibrium with AC vertical. Find m. [2]

4 A particle of mass 0.5 kg is rotating on the smooth interior surface of a fixed hollow sphere of radius 5 m. The particle rotates in a horizontal circle at a height of 2 m above the lowest point of the sphere. Calculate

(i) the magnitude of the force exerted by the sphere on the particle, [3]

(ii) the angular speed of the particle, [4]

(iii) the time for one complete revolution. [2]

5 A hill is 200 m long and is inclined at a constant angle of 10° to the horizontal. A cyclist and her bicycle have a combined mass of 75 kg.

(i) The cyclist starts to go down the hill at a speed of $15\,\text{m s}^{-1}$. She freewheels but experiences a constant air resistance and arrives at the bottom of the hill at a speed of $18\,\text{m s}^{-1}$. Calculate the magnitude of the air resistance. [4]

On another occasion, the same cyclist approaches the same hill from the opposite direction. This time there is no air resistance. She maintains a constant speed of $6\,\text{m s}^{-1}$ while going up the hill.

(ii) Find the power of the cyclist. [4]

At the top of the hill, the cyclist reaches level ground and continues to work at the same rate. The air resistance is now 50 N.

(iii) Find the acceleration of the cyclist just after she reaches the level ground. [2]

6 Two small spheres A and B, with masses 0.2 kg and m kg respectively, lie at rest on a smooth horizontal surface. A is projected directly towards B at a speed of $8\,\text{m s}^{-1}$ and hits B. The direction of motion of A is reversed in the collision. The speeds of A and B after the collision are $2\,\text{m s}^{-1}$ and $4\,\text{m s}^{-1}$ respectively. The coefficient of restitution between A and B is denoted by e.

(i) Show that

(a) $m = 0.5$, [2]

(b) $e = 0.75$. [2]

(ii) B continues to move at $4\,\text{m s}^{-1}$ and strikes a wall at right angles. The coefficient of restitution between B and the wall is also 0.75. Calculate the magnitude of the impulse when B hits the wall. [3]

(iii) After B rebounds from the wall there is a second impact between A and B. Calculate the final speeds of A and B. [5]

[Question 7 is printed overleaf.]

7

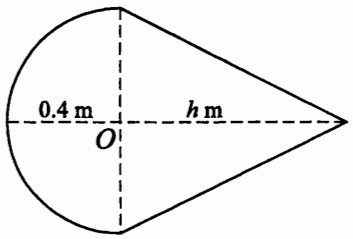


Fig. 1

A toy consists of a uniform solid hemisphere of weight 30 N and a uniform solid cone of weight 5 N. The cone has height h m. The solids have the same base radius 0.4 m and are joined so that their plane faces coincide. The centre of the common face is the point O (see Fig. 1). The centre of mass of the toy lies inside the hemisphere and is at a distance of 0.1 m from O.

(i) Show that $h = 0.8$. [5]

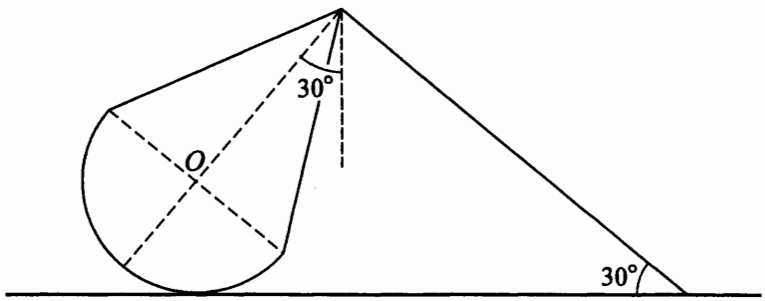


Fig. 2

One end of a light inextensible string is attached to the vertex of the cone and the other end is tied to a fixed point on rough horizontal ground. The toy rests in equilibrium on the ground with its axis of symmetry making an angle of 30° with the vertical. The string makes an angle of 30° with the horizontal (see Fig. 2). The tension in the string is T N and the frictional force acting on the toy is F N.

(ii) By taking moments about O, show that $16T + 8F = 35$. [3]

(iii) Find another equation connecting T and F. Hence calculate the tension and the frictional force. [4]

±1 in 3rd sig fig 5 ✓ 5 AG

1	(i)	3800 ─ R = 1000 x 3	M1		use of F=ma (needs 3 parts)
		R = 800 N	A1	2	
	(ii)	P = Fv	M1		3800x8 only unless MR
		P = 30 400 W	A1	2	or 30.4 kW **4**

2	(i)	$-100 = 30\sin25°t - 4.9t^2$ or 2 equations	M1		or for 2 sections of time
		correct quad or via 2 correct equations	A1		B1 1.29 (up) / 2.59 (across)
		for attempting to solve quad or 2 equat's	M1		B1 4.70(down)/3.41(down)
		t = 5.99 or 6.00	A1	4	could be 6.00/6.0/6
	(ii)	s = 30cos25° x 5.99	M1		
		s = 163 m	A1 ✓	2	✓ on their t
		((Alternatively for (i) & (ii)			
		$y = x\tan\theta - gx^2\sec^2\theta/2V^2$ aef	((B1		correct formula
		sub y = ─100 in equ of traj	M1		
		Solve quad.	M1		
		Solve to give x = 163	A1		
		Use s = ut for horizontal motion	M1		
		t=5.99 or 6.00))	A1✓))		✓ on their x **6**

3	(i)	use of cof m2/3 along median of △fromB	M1		
		(160+48)d=160x(6+5)+2/3x6x48	M1		or 208 $\bar{y}$ = 160x5 + 48 x12 ($\bar{y}$ =6.615) negatives OK
		d = 9.38 cm	A1	3	**AG** (no incorrect w. seen)
	(ii)	tanθ=3.38/8 (or 3.38/5)	M1		or 8/3.38, 5/3.38 not sin/cos
		θ=22.9°	A1	2	
	(iii)	mx6=3.38(5) x 1.3 or 1x5=48/160x2+6m	M1		or (m+1.3)x6=1.3x9.38 (m+1.3)x10=1x5+.3x12+16m (m+1.3)x6=1x11+0.3x4
		m = 0.733	A1	2	**7**

4	(i)	Rcosθ = 0.5 x 9.8	M1		for resolving vertically
		3/5R = 0.5 x 9.8	A1		correct use of cosθ = 3/5
		R = 8.17 N	A1 ✓	3	✓ for use of sinθ (6.125)
	(ii)	r = 4	B1		
		Rsinθ = 0.5 x 4 x ω^2 ($mr\omega^2$ can be wrong)	M1		for resolving horizontally
		ω = ƒ(8.17x0.8/0.5x4)	M1		solve ω from $mr\omega^2$(correct)
		ω = 1.81 $rads^{-1}$	A1	4	
	(iii)	T = 2Π/1.81	M1		
		T = 3.47 or 3.48 s	A1 ✓	2	✓ their ω **9**

5	(i)	mgh=75x9.8x200xsin10°	B1		M1 for $18^2=15^2 + 2ax200$
		work done against resistance=200R	B1		A1 a = 0.2475
		$0.5x75x15^2 + mgh = 0.5x75x18^2+200R$	M1		M1 75gsin10°-R=75x0.248
		R=109 N	A1	4	
	(ii)	D=75x9.8xsin10°	M1		B1 tot. WD=75x200gsin10°
		D = 128 (may be implied)	A1		B1 t = 200/6 (33.3)
		P=127.6x6	M1		M1 power = WD/t
		P=766 W	A1 √	4	√their Dx6 ,theirWD/their t
	(iii)	77.6=75a	M1		use of "F=ma"with driv.f─R
		a=1.03 or 1.04 ms^{-2}	A1 √	2	√ on their (D─50)/75 **10**

6	(i)a)	8 x 0.2 = 4m ─ 2 x 0.2	M1		use of cons. of mom.
		m = 0.5	A1	2	**AG**
	b)	use of rel. separation/rel. approach	M1		
		e = ¾	A1	2	**AG**
	(ii)	B's speed = 3 (accept –3)	B1		may be implied
		I = 0.5 x 3 ─ ─ 0.5 x 4	M1		use of cons. of mom.
		I = 3.5 Ns	A1	3	
	(iii)	2x0.2 + 3x0.5 = 0.2x + 0.5y	M1		use of cons. of mom.
		¾ = x ─ y	M1		use of coeff of rest.
		solving sim equ	M1		one soln. sufficient
		x = 3.25 ms^{-1} (A) ; y = 2.5 ms^{-1} (B)	A1+A1	5	Max A1 only any negatives in final answer **12**

7	(i)	centre of mass of cone = ¼ *h*	B1		
		" " " " hemisphere = 3/8 x 0.4	B1		(0.15)
		0.05 x 30 = (¼ *h*+0.1)x5 or = 0.3 x 5 if h is assumed to be 0.8	M1 A1		M(G) G is c. of m. of toy
	alternatively	0.05 x 35 = (¼ *h*+0.15)x5 or = 0.35 x 5 if h is assumed to be 0.8	(M1) (A1)		M(H) H is c. of m. of hemisp.
	or	0.3x35 = 0.25x30 + (0.4 + ¼ *h*)x5 or = 0.25x30 + 0.6x5 h is ass'd to be 0.8	(M1) (A1)		M(A) A is hemisphere base pt
	or	(*h*+0.1)x35=(*h*+0.15)x30 + 2*h* x 5 or 0.9x35=0.95x30+0.6x5 if h is ass'd 0.8	(M1) (A1)		M(B) B is vertex of cone
	or	0.1 x 35 = 0.15 x 30 - ¼ *h* x 5 or = 0.15x30–0.2x5 if h is ass'd to be0.8	(M1) (A1)		M(O)
	or	(¼ *h*+0.1)x35 = (¼ *h*+0.15)x30 or 0.3x35=0.35x30 if h is ass'd to be 0.8	(M1) (A1)		M(C) C is c. of m. of cone
		h = 0.8 (can be implied by verification)	A1	5	**AG**(if not derived then matching values must be demonstrated)
	(ii)	Tx0.8 + Fx0.4 = 35x0.1xsin30°	M1		taking moments
		or equivalent	A1		correct equation
		16 T + 8 F = 35	A1	3	**AG** CWO
	(iii)	Tcos30° = F	B1		
		16 F ÷ cos30° + 8F = 35	M1		solve sim equ(1soln.ok)
		F = 1.32	A1		
		T = 1.53	A1	4	**12**