OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 4729

Mechanics 2

Friday **27 JANUARY 2006** Afternoon 1 hour 30 minutes

Additional materials:
8 page answer booklet
Graph paper
List of Formulae (MF1)

TIME 1 hour 30 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.
- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

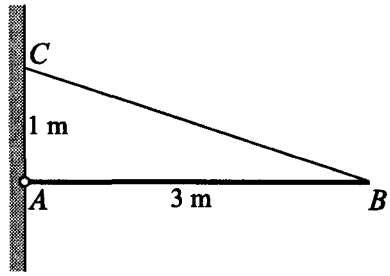
INFORMATION FOR CANDIDATES

- 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 72.
- 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 5 printed pages and 3 blank pages.

[Turn over

1



A uniform rod AB has weight 20 N and length 3 m. The end A is freely hinged to a point on a vertica wall. The rod is held horizontally and in equilibrium by a light inextensible string. One end of th string is attached to the rod at B. The other end of the string is attached to a point C, which is 1 n directly above A (see diagram). Calculate the tension in the string. [4

2 A golfer hits a ball from a point O on horizontal ground with a velocity of $50\,\mathrm{m\,s^{-1}}$ at an angle o $25°$ above the horizontal. The ball first hits the ground at a point A. Assuming that there is no ai resistance, calculate

(i) the time taken for the ball to travel from O to A, [3

(ii) the distance OA. [2

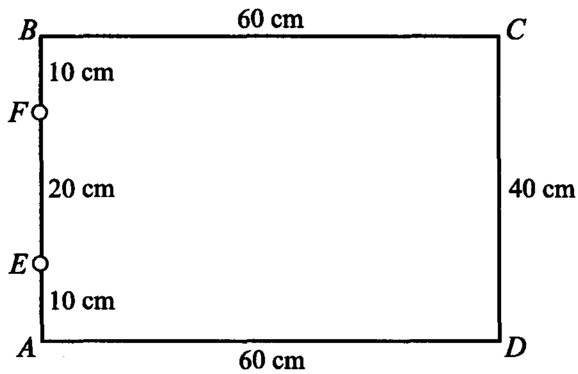
3 A box of mass 50 kg is dragged along a horizontal floor by a constant force of magnitude 400 N actin at an angle of α above the horizontal. The total resistance to the motion of the box has magnitud 300 N. The box starts from rest at the point O, and passes the point P, 25 m from O, with a speed o $2\,\mathrm{m\,s^{-1}}$.

(i) For the box's motion from O to P, find

(a) the increase in kinetic energy of the box, [1

(b) the work done against the resistance to motion of the box. [1

(ii) Hence calculate α. [3

4 

A rectangular frame consists of four uniform metal rods. AB and CD are vertical and each is 40 cm long and has mass 0.2 kg. AD and BC are horizontal and each is 60 cm long. AD has mass 0.7 kg and BC has mass 0.5 kg. The frame is freely hinged at E and F, where E is 10 cm above A, and F is 10 cm below B (see diagram).

(i) Sketch a diagram showing the directions of the horizontal components of the forces acting on the frame at E and F. [2]

(ii) Calculate the magnitude of the horizontal component of the force acting on the frame at E. [3]

(iii) Calculate the distance from AD of the centre of mass of the frame. [3]

5 Three smooth spheres A, B and C, of equal radius and of masses $3m$ kg, $2m$ kg and m kg respectively, are free to move in a straight line on a smooth horizontal table. Spheres B and C are stationary. Sphere A is moving with speed 2 m s^{-1} when it collides directly with sphere B. The collision is perfectly elastic.

(i) Find the velocities of A and B after the collision. [6]

(ii) Find, in terms of m, the magnitude of the impulse that A exerts on B, and state the direction of this impulse. [2]

Sphere B continues its motion and hits C. After the collision, B continues in the same direction with speed 1.0 m s^{-1} and C moves with speed 2.8 m s^{-1}.

(iii) Find the coefficient of restitution between B and C. [2]

6 A stone is projected horizontally with speed 7 m s^{-1} from a point O on the edge of a vertical cliff. The horizontal and upward vertical displacements of the stone from O at any subsequent time, t seconds, are x m and y m respectively. Assume that there is no air resistance.

(i) Express x and y in terms of t, and hence show that $y = -\frac{1}{10}x^2$. [4]

The stone hits the sea at a point which is 20 m below the level of O.

(ii) Find the distance between the foot of the cliff and the point where the stone hits the sea. [2]

(iii) Find the speed and direction of motion of the stone immediately before it hits the sea. [6]

7 Marco is riding his bicycle at a constant speed of $12\,\mathrm{m\,s^{-1}}$ along a horizontal road, working at a constant rate of 300 W. Marco and his bicycle have a combined mass of 75 kg.

(i) Calculate the wind resistance acting on Marco and his bicycle. [2]

Nicolas is riding his bicycle at the same speed as Marco and directly behind him. Nicolas experiences 30% less wind resistance than Marco.

(ii) Calculate the power output of Nicolas. [2]

The two cyclists arrive at the bottom of a hill which is at an angle of $1°$ to the horizontal. Marco increases his power output to 500 W.

(iii) Assuming Marco's wind resistance is unchanged, calculate his instantaneous acceleration immediately after starting to climb the hill. [5]

Marco reaches the top of the hill at a speed of $13\,\mathrm{m\,s^{-1}}$. He then freewheels down a hill of length 200 m which is at a constant angle of $10°$ to the horizontal. He experiences a constant wind resistance of 120 N.

(iv) Calculate Marco's speed at the bottom of this hill. [5]

8

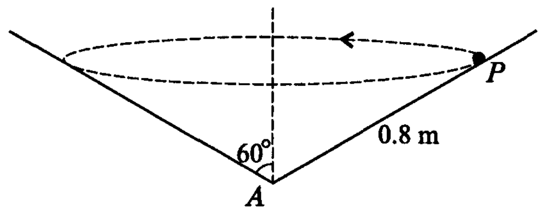


Fig. 1

A particle P of mass 0.1 kg is moving with constant angular speed ω rad s^{-1} in a horizontal circle on the smooth inner surface of a cone which is fixed with its axis vertical and its vertex A at its lowest point. The semi-vertical angle of the cone is 60° and the distance AP is 0.8 m (see Fig. 1).

(i) Calculate the magnitude of the force exerted by the cone on the particle. [3]

(ii) Calculate ω. [4]

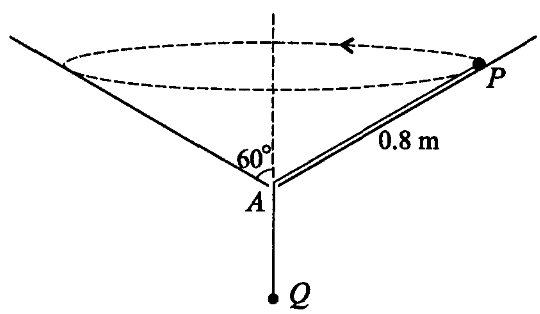


Fig. 2

The particle P is now attached to one end of a light inextensible string which passes through a small smooth hole at A. The lower end of the string is attached to a particle Q of mass 0.2 kg. Q is in equilibrium with the string taut and AP = 0.8 m. P moves in a horizontal circle with constant speed v m s^{-1} (see Fig. 2).

(iii) State the tension in the string. [1]

(iv) Find v. [6]

1		tanθ = ⅓ (θ = 18.4° at B)	B1		71.6° at C	
		3 x T sinθ = 20 x 1.5 must	M1		M(A) (d=3/√10)	
		have two distances and no g	A1			
		T = 31.6 N	A1	4		4

2	(i)	$0 = 50 \sin25° t - 4.9t^2$	M1		or 0=50sin25° - 9.8t &2t :2x2.16	
			A1			
		t = 4.31 s	A1	3		
	(ii)	d = 50cos25° x 4.31	M1		or $u^2\sin(2x25°)/g$	
		195 m	A1√	2	√ 50cos25° x their t	5

3	(i)a	100 J	B1	1		
	b	7500 Nm	B1	1		
	(ii)	400cosα x 25 =7500 + 100	M1		sc N II gets M1A1only.This M1	
		√ for = a + b	A1√		for total M (a=0.08)&A1for α	
		α = 40.5	A1	3	or 0.707 rads	5

4	(i)	horiz comps in opp direct	B1		at E & F	
		Right at E + Left at F	B1	2		
	(ii)	1.6x9.8x30 = 20X or	M1		or 10X + 1.6gx30 = 30X M(A)	
		0.5x30g + 0.7x30g + 0.2x60g = 20X	A1		or 10X + (. . . = 470.4) = 30X M mark ok without g but 3 parts	
		X = 23.5 N	A1	3		
	(iii)	$1.6\bar{y}$ =	M1		must be moments with vert dists	
		20x0.2 + 20x0.2 +40x0.5	A1		or $1.6\bar{y}$=20x0.2x2+40x0.7(22.5)	
		$\bar{y}$ = 17.5 cm	A1	3		8

5	(i)	6m = 3mx + 2my	M1		- 3mx ok if clear on diagram	
		6 = 3x + 2y	A1		m must have been cancelled	
		e = 1 = (y-x)/2	M1		**or** $½.3m.2^2 = ½.3mx^2 + ½.2my^2$	
			A1		$6 = 3x^2/2 + y^2$ aef	
		x = 0.4 or 2/5	A1		sc A1A0 if x = 2, y = 0 not	
		y = 2.4 or 12/5	A1	6	rejected	
	(ii)	4.8m or 24m/5	B1√		√ 2m x their y or 3m(2-their x)	
		same as original dir. of A	B1	2	use their diagram(or dir. of B)	
	(iii)	e = (2.8 – 1.0)/2.4	M1			
		0.75 watch out for ± fiddles	A1√	2	√(1.8/their y) with 0 ≤ e ≤ 1	10

6	(i)	x = 7t	B1			
		y = - 4.9t^2 or -½gt^2	M1		some attempt at vertical motion	
			A1		sc y=xtanθ $-$gx^2/(2V^{2}cos^{2}θ)	
		y = - x^2/10 **AG** (no fiddles)	A1	4	with θ=0 M1 then A1 (max = 2)	
	(ii)	-20 = -x^2/10	M1		or t=√(20/4.9) & x=7t	
		14.1 m	A1	2	sc B1 for 14.1 after wrong work	
	(iii)	½mv^2 = ½m7^2 + mgx20 n.b. v^2=u^2	M1		**OR** v$_h$ = 7 (B1)	
		+2as gets M0	A1		v$_v$ = ±19.8 (B1) 14√2,2√98 etc	
		v = 21 ms^{-1}	A1		v = 21 (B1)	
		dy/dx = -2x/10 & tanθ	M1		**OR** tanθ = 19.8/7 or	
			A1		cosθ=7/21 or sinθ=19.8/21	
		70.5° to horizontal	A1	6	or 19.5° to vertical	**12**

7	(i)	F = 300/12	M1			
		R = 25	A1	2		
	(ii)	P=17.5x12 (R$_2$=17.5 & F$_2$ = 17.5)	M1		n.b. B1 only for 210 W	
		P = 210 W	A1	2	without working	
	(iii)	500 = Fx12	M1			
		F = 41.67 or 500/12 aef	A1			
		41.67 – 25 – 75x9.8sin1°= 75a	M1			
			A1			
		0.0512 ms^{-2}	A1	5	or 0.051	
	(iv)	PE = 75x9.8x200sin10° (25530)	B1		**OR** 75x9.8sin10° -120= 75a	
		WD = 200x120 (24000)	B1		(M1 + A1)	
		½.75v^2 =	M1		a = 0.102 (A1)	
		½.75.13^2+75x9.8x200sin10°-200.120	A1		v^2 =169+2x0.102x200 (M1)	
		14.5 ms^{-1}	A1	5	v = 14.5	**14**

8	(i)	R cos30° = 0.1 x 9.8	M1		resolving vertically	
			A1			
		R = 1.13 N	A1	3		
	(ii)	r = 0.8cos30° = 0.693 or 2√3/5	B1		may be implied	
		Rcos60° = 0.1 x 0.693 ω^2	M1		or 0.1v^2/r & ω = v/r	
			A1			
		ω = 2.86	A1	4		
	(iii)	T = 1.96 N	B1	1		
	(iv)	Rcos30° = Tcos60° + 0.1x9.8	M1			
			A1			
		R = 2.26 N	A1			
		Rcos60° + Tcos30° = 0.1 x v^2/r	M1		or mrω^2 & use of v = rω	
			A1		with R=1.13 can get M1 only	
		4.43 ms^{-1}	A1	6		**14**
or	(iv)	LHS (or RHS)	M1*		method without finding R	
		T + 0.1x9.8cos60°	A1		i.e. resolving along PA	
		RHS (or LHS)	M1*			
		0.1 x v^2/r x cos30°	A1		r to be 0.8 cos30° for A1	
		solve to find v	M1*		depends on 2* Ms above	
		4.43 ms^{-1}	A1	(6)		