OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2637

Mechanics 1

Friday **21 JANUARY 2005** 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 Two small spheres A and B, of masses 0.3 kg and 0.2 kg respectively, are moving on a smooth horizontal table and collide. Immediately before the collision A and B are moving directly towards each other with speeds $1.5\,\text{m s}^{-1}$ and $2\,\text{m s}^{-1}$ respectively. Immediately after the collision A and B move away from each other with speeds of $a\,\text{m s}^{-1}$ and $b\,\text{m s}^{-1}$ respectively.

(i) Show that $b = 0.25 + 1.5a$. [4]

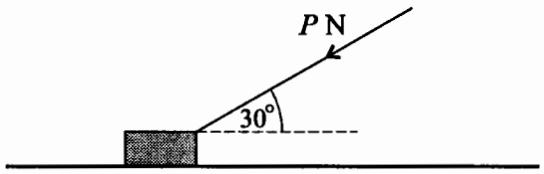
After the collision sphere A travels a distance of 2 m in 4 s.

(ii) Find the values of a and b. [2]

2 A block of mass 3 kg is at rest on a rough horizontal plane.

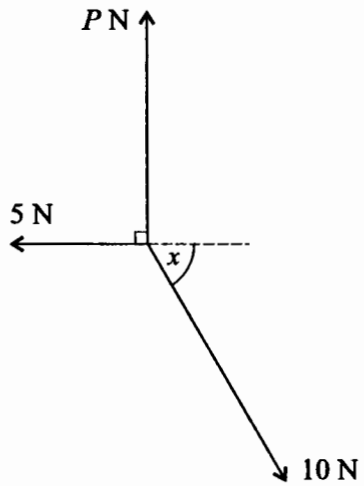
(i) The block is acted on by a horizontal force of magnitude 14.7 N. Given that the block is on the point of sliding, find the coefficient of friction between the block and the plane. [3]

(ii)



The horizontal force is now replaced by a force of magnitude P N acting downwards at 30° to the horizontal (see diagram). Given that the block is again on the point of sliding, find the value of P. [4]

3



The diagram shows the magnitudes and directions of three coplanar forces which act at a point.

(i) Find the value of P and the value of x in degrees for which the forces are in equilibrium. [4]

(ii) Find the magnitude of the resultant of the forces when $P = 12$ and $x = 45°$. [4]

4 A particle moves in a straight line. At time t s the acceleration of the particle is $3t^{\frac{1}{2}}$ m s^{-2}. When $t = 0$ the particle is at the point O, and when $t = 9$ the particle is at the point P and is moving with velocity 60 m s^{-1}. Find

(i) the velocity of the particle at O, [4]

(ii) the distance OP. [4]

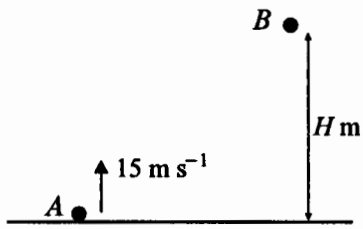
5 A cyclist travels along a straight road from the point O to the point A where he immediately turns round and returns directly to O. On the outward journey the cyclist starts from rest and accelerates uniformly for 20 s, reaching a speed of 9 m s^{-1}. He then cycles at a constant speed of 9 m s^{-1} for 82 s before decelerating uniformly for 8 s, coming to rest instantaneously at A. On the return journey the cyclist accelerates at 0.5 m s^{-2} until his speed reaches 8 m s^{-1}. He then cycles at a constant speed of 8 m s^{-1} until he reaches O.

(i) Sketch the (t, v) graph for the cyclist's whole journey (outward and return). [3]

(ii) Find the distance OA. [2]

(iii) Find the total time taken for the whole journey. [4]

6



A particle A is projected vertically upwards from horizontal ground with speed 15 m s^{-1}. At the same instant a particle B is released from rest at a height H m above the ground (see diagram).

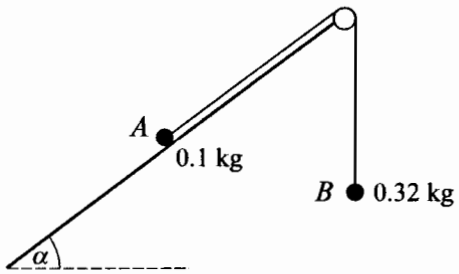
(i) Find the height of A after 0.8 s. [2]

(ii) Find the value of H, given that A and B are at the same height after 0.8 s. [2]

(iii) Show that the time interval between the instant that B reaches the ground and the instant that A returns to the ground is approximately 1.5 s. [5]

[Question 7 is printed overleaf.]

7



Particles A and B, of masses 0.1 kg and 0.32 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley at the top of a rough plane which is inclined at an angle α to the horizontal. It is given that $\sin\alpha = 0.6$ and $\cos\alpha = 0.8$. Particle A is held in contact with the plane and particle B hangs vertically below the pulley (see diagram). The coefficient of friction between A and the plane is $\frac{1}{4}$. Particle A is released and the system starts to move. Find

(i) the acceleration of A, [7]

(ii) the distance travelled by A when its speed has reached $2.8\,\mathrm{m\,s^{-1}}$ (assuming that A has not reached the pulley). [2]

When the speed is $2.8\,\mathrm{m\,s^{-1}}$ the string breaks. Particle A continues to move up the plane without reaching the pulley.

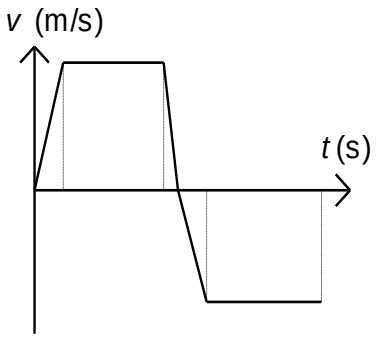
(iii) Find the distance between the initial position of A and the highest point reached by A. [4]

1	**(i)**	Momentum before collision = $0.3\times1.5 - 0.2\times2$ Momentum after collision = $0.2\times b - 0.3\times a$ $0.45 - 0.4 = 0.2b - 0.3a$ $b = 1.5a + 0.25$ **A.G.**	 B1 B1 M1 A1	 4	Alternatively: Momentum lost by A $= 0.3\times1.5 + 0.3\times a$ B1 Momentum gained by B $= 0.2\times b + 0.2\times2$ B1 For using the principle of conservation of momentum
	(ii)	$a = 2/4 = 0.5$ $b = 1.5\times0.5 + 0.25 = 1$	B1 B1ft	2	

2	**(i)**	$F = 14.7$ and $R = 3g$ $14.7 = 3\times9.8\,\mu$ Coefficient is 0.5	B1 M1 A1	 3	For using $F = \mu R$
	(ii)	$F = P\cos30^o$ $R = 3g + P\sin30^o$ $0.866P = 0.5(29.4 + 0.5P)$ ➔ $0.616P = 14.7$ $P = 23.9$	B1 B1 M1 A1	 4	For using $F = \mu R$ and attempting to solve for P

3	**(i)**	$10\cos x = 5$ $x = 60$ $P = 10\sin x$ or $P^2 = 10^2 - 5^2$ $P = 8.66$ or $5\sqrt{3}$	M1 A1 M1 A1	 4	For resolving in **i** direction or using trigonometry to find x in triangle of forces For resolving in **j** direction or using trigonometry or Pythagoras to find P in triangle of forces SR scale drawing (max 3 out of 4) Correct triangle of forces drawn to scale M1, then by measurement, magnitude of P = 8.6 or 8.7 (2sf) A1 x = 60 (2sf) A1
	(ii)	$H = 10\cos45^o - 5$ $V = 12 - 10\sin45^o$ $R^2 = 2.071^2 + 4.929^2$ Magnitude is 5.35 N	B1 B1 M1 A1	 4	For using $R^2 = H^2 + V^2$ Alternatively for the above 4 marks: If combining two forces initially then combining this resultant the third force M1 for a complete method, A1 for the magnitude of the two forces, A1 for angle from those forces, A1 for 5.35. SR scale drawing (max 2 out of 4) Correct polygon of forces drawn to scale M1, then by measurement, magnitude is 5.3 or 5.4 (2sf) A1

4	**(i)**		M1	For using $v = \int a\,dt$
		$v = 2t^{1.5}$ (+ C)	A1	
		$2(9)^{1.5} + C = 60 \rightarrow C = 6$	M1	For using $v(9) = 60$
		Initial velocity is 6 ms^{-1}	A1 4	
	(ii)		M1*	For using $s = \int v\,dt$
		$s = 0.8t^{2.5} + 6t$	A1ft	ft incorrect non zero v_0
		$OP = (0.8(9)^{2.5} + 6\times 9) - (0 + 0)$	M1	For correct use of limits or equivalent
		(= 194.4 + 54)	dep*	
		Distance OP is 248(.4) m	A1 4	

5	**(i)**		M1 A1 B1 3	For an attempt at sketching the graph for the outward stage; v must be continuous, ≥ 0 and single valued throughout, and the graph must consist of 3 straight line segments 1st line segment must start at the origin and have +ve slope, 2nd line segment must have zero slope, 3rd line segment must have –ve slope and terminate on t axis. Values of v and t need not be shown. Correct sketch of the graph for the return stage; values of v and t need not be shown.
	(ii)	OA = ½ 20×9 + 82×9 + ½ 8×9 = 90 + 738 + 36	M1	For using the idea that the distance is represented by the area of the relevant region
		Distance OA is 864 m	A1 2	
	(iii)	Δt = 16	B1	For time of acceleration stage on return journey
		Distance at constant speed = $864 - \frac{1}{2}\,16\times 8$	M1	For correct method of finding a distance at constant speed
		110 + 16 + 800/8	M1	For correct method for finding total time
		Total time is 226 s	A1ft 4	ft for 118 + ans(ii)/8

6	**(i)**	$h = 15\times\ 0.8 - ½\ 9.8\times\ (0.8)^2$ $= 12 - 3.136$ Height is 8.86(4) m	M1 A1	2	For using $s = ut - ½\ gt^2$
	(ii)	$H - ½\ 9.8\times\ (0.8)^2 = 8.864$ or $H = 15\times\ 0.8$ $H = 12$	M1 A1	2	For using $H - ½\ gt^2$ = ans(i) or $H = ut$ (from $H - ½\ gt^2 = ut - ½\ gt^2$)
	(iii)	$0 = 15t - 4.9t^2,\ t \neq 0$ or $0 = 15 - 9.8(t/2)$ $t_A = 3.06$ or $15/9.8$ $12 = ½\ 9.8t^2$ $t_B = 1.56$ or $\sqrt{24/9.8}$ $t_A - t_B = 3.061 - 1.565$ Time interval is approx 1.5 s **A.G.**	M1 A1 M1 A1ft B1	5	For solving $0 = ut - ½\ gt^2,\ t \neq 0$ or for solving $0 = u - g(t/2)$ or equivalent For solving $H = ½\ gt^2$ www

7	**(i)**	 $0.32g - T = 0.32a$ $T - 0.1g\sin\alpha - F = 0.1a$ $R = 0.1g\cos\alpha$ $F = ¼\ (0.08g)$ $0.32g - 0.06g - 0.02g = 0.42a$ $0.42a = 0.24\times 9.8$ Acceleration is 5.6 ms^{-2}	M1 A1 A1 B1 M1 A1 A1	7	For applying Newton's second law to either particle For using $F = \mu R$ For a correct equation in a only
	(ii)	$2.8^2 = 2\times 5.6s$ Distance is 0.7 m	M1 A1ft	2	For using $v^2 = 2as$ ft 3.92/ans(i)
	(iii)	$0.1a = -0.06g - 0.02g$ $a = -0.8g$ $0 = 2.8^2 + 2(-7.84)s_2$ $s_1 + s_2 = 0.7 + 0.5$ Distance is 1.2 m	M1 A1ft M1 A1ft	4	For applying Newton's second law to A (continuing upwards) ft incorrect magnitude of frictional force and/or weight component. Signs must be correct. For using $0 = u^2 + 2as$ to find s_2 ft incorrect ans(ii)