OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2637

Mechanics 1

Wednesday **16 JUNE 2004** Afternoon 1 hour 20 minutes

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

TIME 1 hour 20 minutes

INSTRUCTIONS TO CANDIDATES

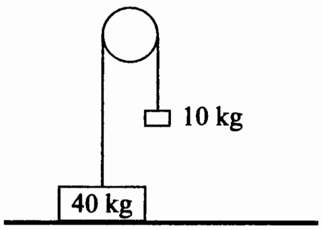
- Write your Name, Centre Number and Candidate Number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- Where 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.**

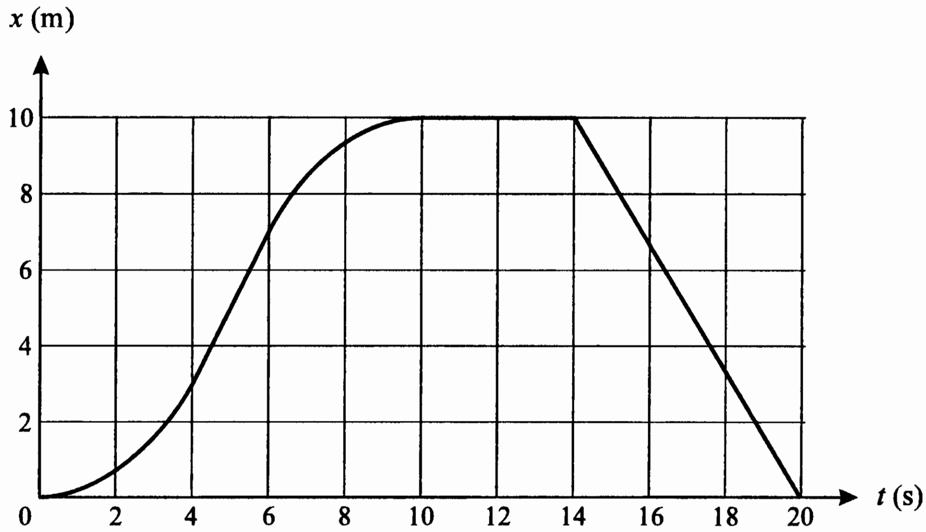
This question paper consists of 4 printed pages.

1



One end of a light string is attached to a block of mass 40 kg which is at rest on a horizontal shelf. The string passes over a fixed smooth pulley and a block of mass 10 kg is attached to the other end of the string. The parts of the string between the blocks and the pulley are vertical (see diagram). Find the magnitude of the force exerted by the shelf on the 40 kg block. [3]

2



The diagram shows the (t, x) graph for the motion of a particle during the interval $0 \leqslant t \leqslant 20$, where x is in metres and t is in seconds.

(i) Use the graph to find the maximum speed of the particle while it is moving away from its starting point. Give your answer in m s^{-1} to 1 significant figure. [3]

(ii) State how long the particle is at rest during the interval $0 \leqslant t \leqslant 20$. [1]

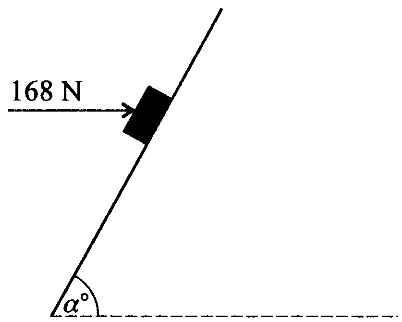
(iii) Find the speed of the particle while it is moving towards its starting point. [2]

3 A train starts from rest at station A and travels to station B where it comes to rest again. The displacement of the train from A at time t s after leaving A is x m, where $x = 0.06t^2 - 0.0001t^3$.

(i) Find an expression for the velocity of the train in terms of t, and hence find the time taken for the train to travel from A to B. [4]

(ii) Find the distance AB. [2]

4



A smooth plane is inclined at $\alpha°$ to the horizontal. A block of mass 5 kg is held at rest on the plane by a horizontal force of magnitude 168 N (see diagram). Find, in either order,

(i) the value of α,

(ii) the magnitude of the normal force exerted by the plane on the block. [6]

The horizontal force is now removed.

(iii) Find the distance travelled by the block in 0.8 s. [4]

5 A box of mass 6.3 kg stands on the floor of a lift which is moving with an upward acceleration of $0.2\ \mathrm{m\,s^{-2}}$. A horizontal force of magnitude 16 N acts on the box. There is no horizontal movement of the box.

(i) Find the magnitude and direction of the resultant of the forces, normal and frictional, exerted by the floor on the box. [7]

The magnitude of the horizontal force acting on the box is increased to X N, and the box is now on the point of sliding horizontally.

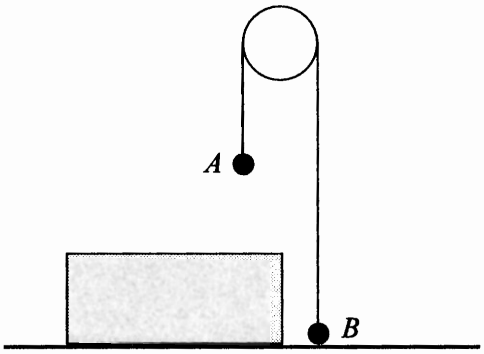
(ii) Given that the coefficient of friction between the floor and the box is 0.3, find the value of X. [2]

The lift is now moving with a **downward** acceleration.

(iii) State, giving a reason, whether the magnitude of the horizontal force necessary to move the box horizontally is greater than, less than, or equal to X N. [2]

[Questions 6 and 7 are printed overleaf.]

6



Particles A and B, of masses 0.9 kg and 0.5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The string is taut and the two parts which are not in contact with the pulley are vertical. The system is released from rest with A vertically above a horizontal step and with B on the floor (see diagram).

(i) For the motion before A hits the step, find the acceleration of A and the tension in the string. [5]

Particle A reaches the step 0.8 s after the system is released from rest. A then remains at rest on the step, the string becomes slack and B continues to rise.

(ii) Find the greatest height above the floor reached by B. [4]

(iii) Find the time for which A is at rest on the step before starting to move upwards. [2]

7 Two small blocks A and B have masses 0.36 kg and 0.32 kg respectively. Block B is stationary on an ice rink 17 m from a boundary wall. Block A is moving at $8\ \mathrm{m\,s^{-1}}$ at right angles to the boundary wall when it strikes B. Block A continues in the same direction, and its speed immediately after the collision is $2.4\ \mathrm{m\,s^{-1}}$.

(i) Find the speed with which B starts to move. [4]

(ii) Given that B moves with constant retardation, and reaches the boundary wall with speed $5.6\ \mathrm{m\,s^{-1}}$, find the coefficient of friction between B and the surface of the ice. [5]

Block B rebounds from the wall in the reverse direction and comes to rest 4 m from the wall. [You may assume that A and B do not collide again.]

(iii) Find the change in B's momentum as a result of its impact with the wall. [4]

1		$T = 10g$	B1	
		$R = 40g - T$ aef	B1	
		Magnitude of the force is 294 N or 30g	B1 3	SR g omitted
				R = 30N B1 (1 out of 3)

2	**(i)**		M1	For using the idea that speed is obtained as the slope of the curve
		eg $\frac{7-3}{6-4}$ or $\frac{10-0}{7.5-2.5}$	M1	For attempting to find the slope at the steepest part of the curve
		Maximum speed is 2 ms^{-1} cao	A1 3	
	(ii)	At rest for 4 s	B1 1	
	(iii)	Slope is $-\frac{10}{6}$ or $\left\lvert\frac{\Delta x}{\Delta t}\right\rvert = \frac{10}{6}$	B1	
		Speed is 1.67 ms^{-1} or 5/3 ms^{-1} or 10/6 ms^{-1}	B1 2	Positive value only

3	**(i)**		M1	For differentiating x
		$v = 0.12t - 0.0003t^2$	A1	
		$0.0003t(400 - t) = 0$	M1	For solving $v = 0$
		Time taken is 400 s	A1 4	
	(ii)	9600 – 6400	M1	For substituting time taken into $x(t)$
		Distance is 3200 m	A1 ft 2	

4	**(i)**	$N \sin \alpha = 168$ and $N \cos \alpha = 49$	M1 A1	For resolving forces both horizontally and vertically - - - First alternative for the above two marks: $N \sin \alpha = 168$ B1 $N \cos \alpha = 49$ B1 - - - Second alternative for the above two marks: For using Lami's theorem to obtain two independent equations M1 $\frac{N}{\sin 90} = \frac{168}{\sin(180 - \alpha)} = \frac{49}{\sin(90 + \alpha)}$ A1 - - - Third alternative for the above two marks: Triangle of forces sketched or implied with a right angle shown or implied and sides containing the right angle shown or implied to be 168 and *W* M1 *W* = 49 shown or used, *N* shown or used as hypotenuse and α shown or used as the angle opposite 168 A1 - - - Fourth alternative for the above two marks: For resolving the forces parallel to the plane M1 $49\sin\alpha = 168\cos\alpha$ A1
		$\tan\alpha = 168/49$ or $\sin \alpha = 168/175$ or $\cos \alpha = 49/175$ $\alpha = 73.7$	M1 A1	For obtaining a value for $\tan\alpha$ by eliminating *N* from simultaneous equations, or by using $\sin(180 - \alpha) = \sin\alpha$ and $\sin(90 + \alpha) = \cos\alpha$ in Lami's theorem or for obtaining a value for $\tan\alpha$ (or $\cos\alpha$ or $\sin\alpha$) from the triangle of forces or for obtaining a value of $\tan\alpha$ from $49\sin\alpha = 168\cos\alpha$
	(ii)	$N^2 = 49^2 + 168^2$ or $N\sin 73.7 = 168$ or $N\cos 73.7 = 49$ or $N = 168\sin \alpha + 49\cos \alpha$ Magnitude of normal force is 175 N	M1 A1 6	For using $\cos^2\alpha + \sin^2\alpha = 1$ to eliminate α from the simultaneous equations or for substituting for α into an appropriate equation or for using Pythagoras' theorem in the triangle of forces or for resolving forces normal to the plane (3 terms)
	(iii)	$5g\sin \alpha = 5a$ $a = 9.41$ (may be implied) $\frac{1}{2}\, 9.41(0.8)^2$ Distance is 3.01 m	M1 A1 M1 A1 ft 4	For using Newton's 2nd law or stating that the acceleration is $g \sin \alpha$ For using $s = \frac{1}{2} at^2$ ft value of *a*

5	**(i)**		M1	For using Newton's 2nd law vertically (3 terms)
		$R - 6.3\times 9.8 = 6.3\times 0.2$	A1	
		$F = 16$ seen or implied	B1	
		$63^2 + 16^2$	M1	For using $\|C\|^2 = R^2 + F^2$
		Magnitude of contact force is 65 N	A1	
		$\tan\alpha = 63/16$	M1	For using $\tan\alpha = R/F$
		Contact force makes an angle of 75.7° or 75.8° or 1.32 rads with the horizontal	A1 7	Or any equivalent direction, stated or clearly shown on a diagram
	(ii)	$F = 0.3\times 63$	M1	For using $F = \mu R$
		$X = 18.9$ N	A1 ft 2	ft value of R
	(iii)	Less than X	*B1	
		Because R is less or friction is less or horizontal force < 18.5(22)N	dep*B1 2	

6	**(i)**		M1	For applying Newton's 2nd law to either A or to B (3 terms)
		$0.9g - T = 0.9a$	A1	Alternative for either of the A marks:
		$T - 0.5g = 0.5a$	A1	$(0.9 - 0.5)\,g = (0.9 + 0.5)a$ B1
		Acceleration is 2.8 ms^{-2}	B1	
		Tension is 6.3 N	A1 5	
	(ii)	s_1 (= ½ $2.8(0.8)^2$) = 0.896	B1 ft	ft value of $\|a\|$
		v ($= 2.8\times 0.8$) = 2.24	B1 ft	ft value of $\|a\|$
		$2.24^2 = 2\times 9.8s_2$	M1	For using $0 = u^2 - 2gs_2$
		Height is 1.152 m (or 1.15 m) (0.896+0.256)	A1 ft 4	ft value of s_1
	(iii)	$2.24 = gt_{\text{up or down}}$ or $-2.24 = 2.24 - gt_{\text{up and down}}$ or $0 = 2.24t - ½g\,(t_{\text{up and down}})^2$ or $0.256 = ½(2.24)\,t_{\text{up or down}}$ or equivalent	B1 ft	ft value of v or s_2
		Time at rest is 0.457 s	B1 2	

7	**(i)**	Momentum before collision = 0.36×8 or Change in A's momentum = $0.36\times8 - 0.36\times2.4$	B1		
		Momentum after collision = $0.36\times2.4 + 0.32v$ or Change in B's momentum = $0.32v$	B1		
		$0.36\times8 = 0.36\times2.4 + 0.32v$ aef	M1		For using the principle of conservation of momentum (3 terms)
		Speed is 6.3 ms^{-1}	A1	4	
					SR g used ($0.36g\times8 = 0.36g\times2.4 + 0.32gv$) Speed is 6.3 ms^{-1} B1 (1 out of 4)
	(ii)	$5.6^2 = 6.3^2 + 2a\times17$	M1		For using $v^2 = u^2 + 2as$ with non-zero u and v
		$a = -0.245$	A1		
		$F = +/- 0.245m_B$	B1ft		ft value of a
		$+/- 0.245m_B = \mu\, 9.8\, m_B$	M1		For using $F = \mu R$ and $R = m_B g$
		Coefficient is 0.025	A1	5	From correct equation only
	(iii)	$0 = u^2 + 2(-0.245)4$	B1		
			M1		For using Change $= +/-(mv_{before} - mv_{after})$
		+/- 0.32(5.6 + 1.4)	A1		
		Change is +/- 2.24 Ns	A1ft	4	ft incorrect positive u