OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS **2637**

Mechanics 1

Friday **19 JANUARY 2001** Morning 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 $9.8\,\text{m}\,\text{s}^{-2}$.
- 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.**

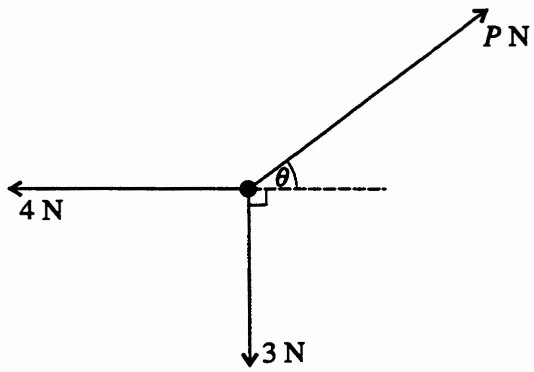
This question paper consists of 4 printed pages.

1 A particle P travels in a straight line with constant acceleration $0.5\,\text{m}\,\text{s}^{-2}$. The initial speed of P is $3\,\text{m}\,\text{s}^{-1}$. Find

(i) the speed of P after 4 s, [2]

(ii) the time taken for P to travel a distance of 55 m. [3]

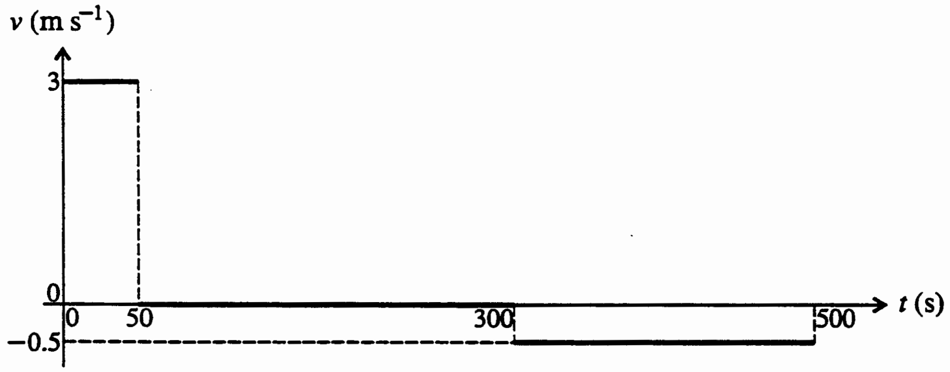
2



(i) Three forces, of magnitudes P N, 4 N and 3 N, act on a particle in the directions shown in the diagram. The particle is in equilibrium. Find P and θ. [4]

(ii) The force of magnitude 4 N is now removed. The magnitudes and directions of the other two forces remain unchanged. Write down the magnitude and direction of the resultant force on the particle. [2]

3



The (t, v) graph shown represents the motion of a first-aider going from a first-aid post to the scene of an accident, and subsequently accompanying the accident victim to a waiting ambulance. All the motion takes place along a straight path.

(i) State how long the first-aider was at the scene of the accident. [1]

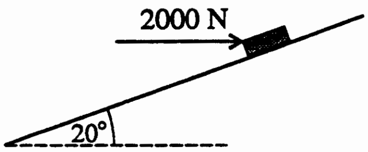
(ii) Find the distance between the first-aid post and the waiting ambulance. [3]

(iii) Sketch the (t, x) graph for the motion of the first-aider, where x metres is the displacement from the first-aid post. Show clearly the values of t and x when the first-aider arrives at the scene of the accident, when he departs from it, and when he arrives at the waiting ambulance. [3]

4 (i) A crate of mass 250 kg rests in equilibrium on a slope inclined at 20° to the horizontal. Find the frictional force acting on the crate. [2]

(ii) Given that the equilibrium is limiting, calculate the coefficient of friction between the crate and the slope. [2]

(iii) The crate is now pushed horizontally with a force of magnitude 2000 N, as shown in the diagram below. Show that the crate remains in equilibrium. [6]



5 Particles A and B, of masses 0.15 kg and 0.2 kg respectively, are free to move on a horizontal surface. Air resistance may be ignored. At a particular instant A is moving with speed $2\,\mathrm{m\,s^{-1}}$ towards B, which is stationary at a point 4 m from A. Particle A collides directly with particle B.

(i) It is given that the horizontal surface is smooth and that A is brought to rest by the collision. Find the speed of B immediately after the collision. [3]

(ii) It is given instead that the coefficient of friction between A and the surface is 0.05. A is again brought to rest by the collision. Find the speed of B immediately after the collision. [7]

6 A particle P travels in a straight line from the point O to the point A and back to O. At time t seconds after starting from O, the displacement of P from O is x m, where $x = 2t^3 - t^4$. Find

(i) expressions for the velocity and acceleration of P, [2]

(ii) the value of t at the instant when P returns to O, [2]

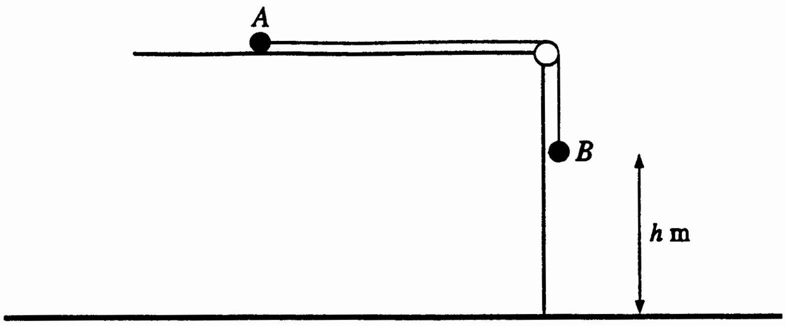
(iii) the speed with which P returns to O, [2]

(iv) the value of t at the instant when P reaches A, [2]

(v) the maximum speed while P is travelling from O towards A. [2]

[Question 7 is printed overleaf.]

7



Particles A and B, each of mass 0.6 kg, are joined by a light inextensible string. The string passes over a smooth pulley at the edge of a smooth horizontal platform. A is held at rest on the platform. B hangs vertically below the pulley at a height h m above the floor, as shown in the diagram. A is released, with the string taut, and the particles start to move. There is no air resistance.

(i) Find the tension in the string and the acceleration of A. [4]

(ii) Hence find the speed of A after it has travelled a distance of 2 m. [2]

(iii) When A has moved a distance of 2 m it becomes detached from the string. From this instant B takes a further 0.2 s to reach the floor. Find the value of h. [3]

(iv) Find also the total time for which B is in motion before it reaches the floor. [3]

1 $v = u + at = 3 + 0\cdot5 \times 4 = \mathbf{5\ ms^{-1}}$ [2]

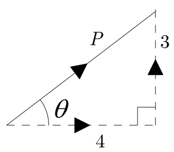
$s = ut + \frac{1}{2}at^2$ $\quad 55 = 3t + 0\cdot25t^2$

$t^2 + 12t - 220 = 0$

$(t+22)(t-10) = 0$

time taken is **10 s** [3]

2



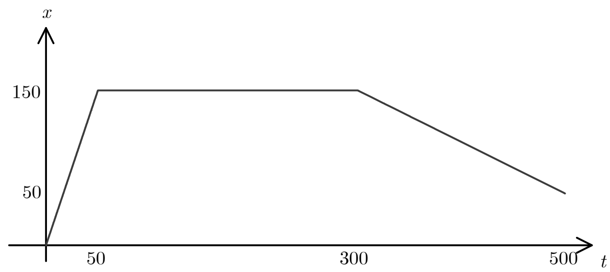
$P = \sqrt{4^2 + 3^2} = \mathbf{5}$ $\qquad \theta = \tan^{-1}\left(\frac{3}{4}\right) = \mathbf{36\cdot9}^\circ$ (3 s.f.) [4]

when 4 N force removed ....

resultant has magnitude **4 N** in the direction opp. to the missing force. [2]

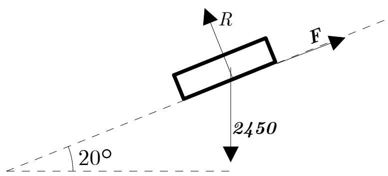
3 time at scene of accident = 300 – 50 = **250 s** [1]

distance from first-aid post to ambulance = 3 x 50 – 200 x 0.5 = **50 m** [3]



[3]

4



N2(up the slope) $\quad F - 2450\sin 20^\circ = 0$

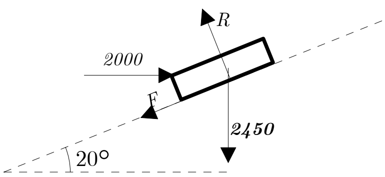
$F = 837\cdot949...$

$= \mathbf{838}$ (3 s.f.) [2]

N2(normal to slope) $\quad R - 2450\cos 20^\circ = 0$

$R = 2302\cdot246...$

limiting equilibrium .... $\quad \mu = \dfrac{F}{R} = \dfrac{837\cdot949...}{2302\cdot24...} = \tan 20^\circ = 0\cdot36397... = \mathbf{0\cdot364}$ (3 s.f.) [2]



N2(normal) $\quad R - 2000\sin 20^\circ - 2450\cos 20^\circ = 0$

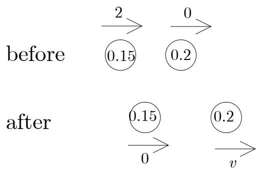
$R = 2986\cdot287...$

limiting friction $= 2986\cdot287... \times 0\cdot36397... = 1086\cdot919...$

$2000\cos 20^\circ - 2450\sin 20^\circ = 1041\cdot43...$

since $1041.43... < 1086.919...$ the crate will remain in equilibrium with friction down the slope. [6]

5

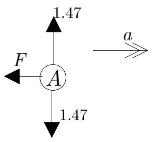


conservation of momentum ….

$$0\cdot 15\times 2 \ + \ 0\cdot 2\times 0 \ = \ 0\cdot 15\times 0 \ + \ 0\cdot 2v_B$$

$$v_B = \mathbf{1\cdot 5\ ms^{-1}}$$ [3]

[2]



N2 $(\rightarrow)$ $\quad {}^{-}1\cdot 47\times 0\cdot 05 = 0\cdot 15a \quad a = {}^{-}0\cdot 49$

$v^2 = u^2 + 2as = 2^2 - 2\times 0\cdot 49\times 4 = 0\cdot 08 \quad v = 0\cdot 28284...$

cons. of mom. ….

$0\cdot 2v_B = 0\cdot 15\times 0\cdot 28284... \quad v_B = 0\cdot 21213... = \mathbf{0\cdot 212\ ms^{-1}}$ (3 s.f.)

[7]

6

$x = 2t^3 - t^4 \quad v = \dfrac{dx}{dt} = \mathbf{6t^2 - 4t^3} \quad a = \dfrac{dv}{dt} = \mathbf{12t - 12t^2}$ [2]

when P is at O … $\quad 2t^3 - t^4 = 0 \quad t^3(2-t) = 0 \quad t = \mathbf{2}$ (on return) [2]

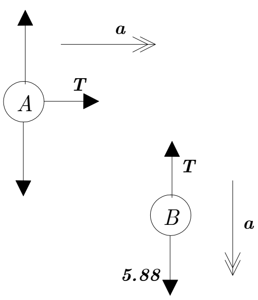
$v(2) = 6\times 2^2 - 4\times 2^3 = -8 \quad \therefore$ speed on return to $O = \mathbf{8\ ms^{-1}}$ [2]

$v = 0$ at $A \quad \Rightarrow \quad 2t^2(3-2t) = 0 \quad \Rightarrow \quad t = \mathbf{\tfrac{3}{2}}$ [2]

maximum speed occurs when $a = 0$

$12t(1-t) = 0 \quad \Rightarrow \quad t = 1 \quad$ so $\quad v_{\max} = 6 - 4 = \mathbf{2\ ms^{-1}}$ [2]

7



$$\left.\begin{aligned} &\boldsymbol{A} \ \ \text{N2}(\rightarrow) \quad & T &= 0\cdot 6a \\ &\boldsymbol{B} \ \ \text{N2}(\downarrow) \quad & 5\cdot 88 - T &= 0\cdot 6a \end{aligned}\right\} \quad \boldsymbol{a} = \mathbf{4.9\ ms^{-2}} \quad \boldsymbol{T} = \mathbf{2.94\ N}$$

[4]

after 2 m …..

$v^2 = u^2 + 2as = 0 + 2\times 2.94\times 2 = 11\cdot 76$

$v = 3\cdot 42928... = \mathbf{3\cdot 43\ ms^{-1}}$

[2]

$h = 2 + \left(ut + \tfrac{1}{2}at^2\right) = 2 + 3\cdot 42928...\times 0\cdot 2 + \tfrac{1}{2}\times 9\cdot 8\times 0\cdot 2^2 = 2\cdot 88185... = \mathbf{2\cdot 88\ m}$ (3 s.f.)

[3]

total time $= 0\cdot 2 + \left(\dfrac{v-u}{a}\right)_{first\ phase} = 0\cdot 2 + \left(\dfrac{3\cdot 42928...}{4\cdot 9}\right) = 0\cdot 899854... = \mathbf{0\cdot 900\ s}$ (3 s.f.) [3]

Total [60]