OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2637

Mechanics 1

Wednesday **21 JANUARY 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 $9.8\,\text{m}\,\text{s}^{-2}$.
- 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.

Registered Charity Number: 1066969
[Turn over

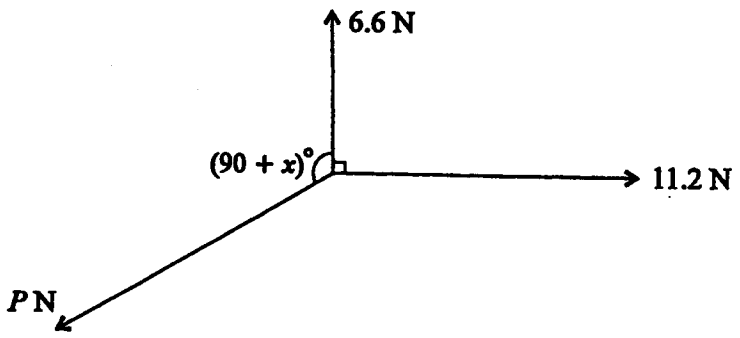
1 Two particles P and Q have masses 0.05 kg and 0.03 kg respectively. The particles are moving towards each other, P with speed $1.2\,\mathrm{m\,s^{-1}}$ and Q with speed $1.3\,\mathrm{m\,s^{-1}}$, when they collide directly. Particle P is brought to rest by the collision. Find the speed of Q immediately after the collision. [4]

2 A particle leaves a point A with speed $1\,\mathrm{m\,s^{-1}}$ and travels with constant acceleration in a straight line to a point B, taking 50 s. The distance AB is 200 m.

(i) Find the acceleration of the particle. [3]

(ii) Find the speed of the particle as it passes through the mid-point of AB. [3]

3



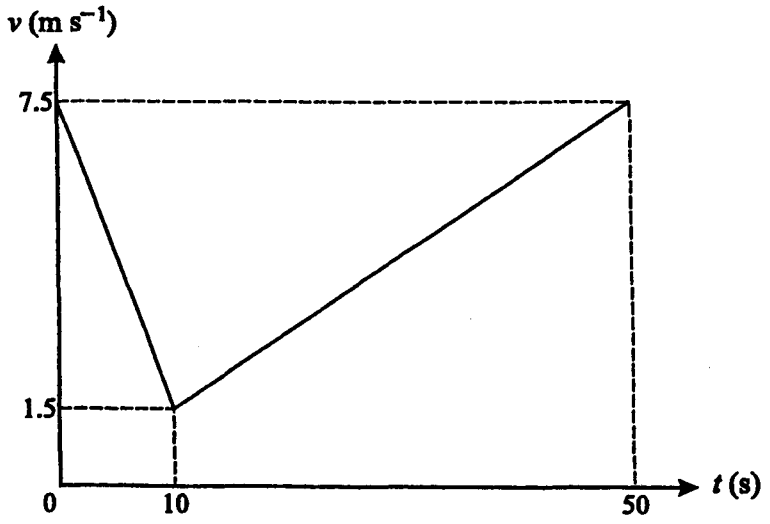
Three coplanar forces have magnitudes and directions as shown in the diagram.

(i) Given that the three forces are in equilibrium, find the values of P and x. [5]

The force of magnitude P N is now removed.

(ii) Write down the magnitude and direction of the resultant of the remaining two forces. [2]

4 Cyclists A and B are moving alongside each other in parallel straight lines, each at a constant speed of $7.5\,\text{m s}^{-1}$, when A starts to decelerate to pick up a bottle of water. His speed as he picks up the bottle is $1.5\,\text{m s}^{-1}$. Cyclist A then accelerates until he reaches his original speed of $7.5\,\text{m s}^{-1}$. Cyclist B continues at $7.5\,\text{m s}^{-1}$ throughout.



The diagram shows the (t, v) graph for A's motion from the instant he starts to decelerate until he regains his original speed. The graph consists of two straight line segments. Find

(i) the acceleration of A during the 40 s after picking up the bottle, [2]

(ii) the distance between B and A at the instant when A regains his initial speed, [5]

(iii) the time interval between B's arrival and A's arrival at the point where A regains his initial speed. [2]

5 A car is towing a trailer along a horizontal straight road using a horizontal tow-bar. The masses of the car and the trailer are 1050 kg and 200 kg respectively. The resistance to motion of the car is 850 N and the resistance to motion of the trailer is 150 N.

(i) At an instant when the driving force exerted by the car is 1100 N, find

(a) the acceleration of the car, [3]

(b) the pulling force exerted on the trailer. [3]

(ii) At another instant the pulling force exerted on the trailer is zero.

(a) Show that the acceleration of the car is $-0.75\,\text{m s}^{-2}$. [2]

(b) Find the driving force exerted by the car. [2]

[Questions 6 and 7 are printed overleaf.]

6 The displacement of a particle at time t seconds after it passes through a fixed point is s m, where $s = 4.8t + 0.06t^2 - 0.004t^3$.

(i) Write down expressions in terms of t for

(a) the velocity of the particle in $\mathrm{m\,s^{-1}}$, [2]

(b) the acceleration of the particle in $\mathrm{m\,s^{-2}}$. [2]

(ii) Find the value of s when the acceleration of the particle is zero. [2]

(iii) Find the distance travelled by the particle from the point where it reaches its maximum velocity to the point where its velocity is half its initial velocity. [5]

7 A board is fixed so that it makes an angle of 11° with the horizontal. A block of mass 0.2 kg is placed on the board and then set in motion with an initial speed of $2\,\mathrm{m\,s^{-1}}$ down a line of greatest slope of the board. The block comes to rest in 4 s. The coefficient of friction between the block and the board is μ. Find

(i) the deceleration of the block, [2]

(ii) the frictional force on the block while the block is in motion, [3]

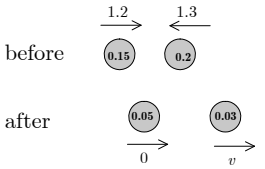
(iii) the value of μ. [3]

With the block at rest on the board, the inclination of the board is gradually increased. The angle that the board makes with the horizontal is α. Find α when

(iv) the block starts to slide, [2]

(v) the block is moving with acceleration $g(1 - \mu)\cos\alpha$. [3]

1



conservation of momentum $(\rightarrow)$

$0\cdot03v = 0\cdot05\times1\cdot2 \;+\; 0\cdot03\times{}^{-}1\cdot3$ $\qquad v = \mathbf{0\cdot7}$

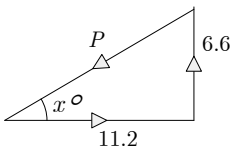
[4]

2

$s = ut + \frac{1}{2}at^2$ $\qquad 200 = 1\times50 + \frac{1}{2}\times a\times50^2$ $\qquad a = \mathbf{0\cdot12}$ [3]

at midpoint, $s = 100$ $\qquad v^2 = u^2 + 2as = 1^2 + 2\times0\cdot12\times100 = 25$ $\qquad v = \mathbf{5}$ [3]

3



The forces are in equilibrium so they sum to form a triangle …

$P = \sqrt{6\cdot6^2 + 11\cdot2^2} = \mathbf{13\cdot0}$ $\qquad x = \tan^{-1}\left(6\cdot6 \big/ 11\cdot2\right) = \mathbf{30\cdot5}$

[5]

When force P is removed, the resultant is of magnitude **13 N** in the direction opposite to force P.

[2]

4

acceleration of $A = (7\cdot5 - 1\cdot5)/40 = \mathbf{0\cdot15}$ **ms^{-2}**

[2]

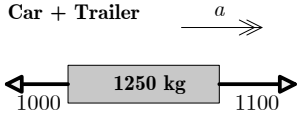
distance A resumes behind B = area of upper triangle $= \frac{1}{2}\times50\times6 = \mathbf{150\ m}$

[5]

time interval $= 150/7\cdot5 = \mathbf{20\ s}$

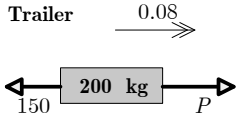
[2]

5



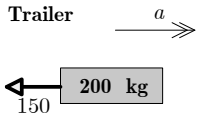
N2$(\rightarrow)$ $\qquad 1100 - 1000 = 1250a$ $\qquad a = \mathbf{0\cdot08}$

[3]



N2$(\rightarrow)$ $\qquad P - 150 = 200\times0\cdot08$ $\qquad P = \mathbf{166}$

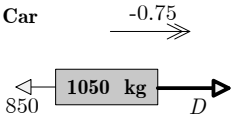
[3]



N2$(\rightarrow)$ $\qquad -150 = 200a$ $\qquad a = {}^{-}0\cdot75$

[2]

and so the acceleration of the car will also be **–0.75 ms^{-2}**



N2$(\rightarrow)$ $\qquad D - 850 = 1050\times{}^{-}0\cdot75$ $\qquad D = \mathbf{62\cdot5}$

[2]

6 $s = 4\cdot8t + 0\cdot06t^2 - 0\cdot004t^3$ $\quad$ $\boldsymbol{v = 4\cdot8 + 0\cdot12t - 0\cdot012t^2}$ $\quad$ $\boldsymbol{a = 0\cdot12 - 0\cdot024t}$ [2], [2]

$a = 0 \quad \Rightarrow \quad t = {}^{0\cdot12}\!/_{0\cdot024} = 5 \quad \Rightarrow \quad s = \mathbf{25}$ [2]

when v is half the initial velocity…

$$4\cdot8 + 0\cdot12t - 0\cdot012t^2 = 2\cdot4$$
$$0\cdot012t^2 - 0\cdot12t - 2\cdot4 = 0$$
$$t^2 - 10t - 200 = 0$$
$$(t-20)(t+10) = 0$$
$$t = 20 \quad (or \quad {}^{-}10)$$

required distance $= \left[4\cdot8t + 0\cdot06t^2 - 0\cdot004t^3\right]_5^{20} = 88 - 25 = \mathbf{63\ m}$ [5]

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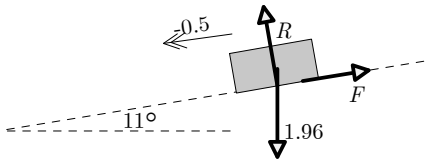
7 deceleration of block $= {}^{2}\!/_{4} = \mathbf{0.5\ ms^{-2}}$ [2]



N2 (down slope) $\quad 1\cdot96\sin11^\circ - F = 0\cdot2\times{}^{-}0\cdot5$

$$F = 0\cdot47398563...$$
$$= \mathbf{0\cdot474} \ \text{(3 s.f.)}$$

[3]

N2 (normal to slope) $\quad R - 1\cdot96\cos11^\circ = 0$

$$R = 1\cdot923989...$$

limiting friction …

$F = \mu R \qquad \mu = {}^{F}\!/_{E} = {}^{0\cdot47398...}\!/_{1\cdot9239...} = 0\cdot246355... = \mathbf{0\cdot246}$ (3 s.f.) [3]

when the block is at rest and just about to slide …

N2 (down slope) $\quad mg\sin\alpha - \mu(mg\cos\alpha) = 0$

$$\mu = \tan\alpha$$
$$\alpha = \tan^{-1}(0\cdot246355...) = \mathbf{13\cdot8^\circ}$$

[2]

when the block is accelerating ….

N2 (down slope) $\quad mg\sin\alpha - \mu(mg\cos\alpha) = mg(1-\mu)\cos\alpha$

$$\sin\alpha = \cos\alpha$$
$$\tan\alpha = 1$$
$$\boldsymbol{\alpha = 45^\circ}$$

[3]