OCR RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 4728

Mechanics 1

Monday **22 MAY 2006** Morning 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.

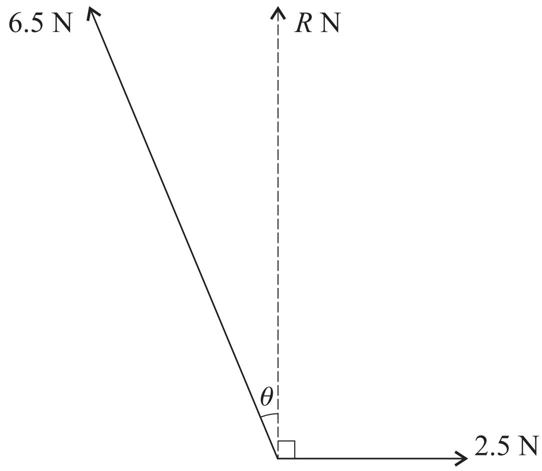
INFORMATION FOR CANDIDATES

- 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 4 printed pages.

1 Each of two wagons has an unloaded mass of 1200 kg. One of the wagons carries a load of mass m kg and the other wagon is unloaded. The wagons are moving towards each other on the same rails, each with speed $3\,\mathrm{m\,s^{-1}}$, when they collide. Immediately after the collision the loaded wagon is at rest and the speed of the unloaded wagon is $5\,\mathrm{m\,s^{-1}}$. Find the value of m. [5]

2



Forces of magnitudes 6.5 N and 2.5 N act at a point in the directions shown. The resultant of the two forces has magnitude R N and acts at right angles to the force of magnitude 2.5 N (see diagram).

(i) Show that $\theta = 22.6°$, correct to 3 significant figures. [3]

(ii) Find the value of R. [3]

3 A man travels 360 m along a straight road. He walks for the first 120 m at $1.5\,\mathrm{m\,s^{-1}}$, runs the next 180 m at $4.5\,\mathrm{m\,s^{-1}}$, and then walks the final 60 m at $1.5\,\mathrm{m\,s^{-1}}$. The man's displacement from his starting point after t seconds is x metres.

(i) Sketch the (t, x) graph for the journey, showing the values of t for which $x = 120$, 300 and 360. [5]

A woman jogs the same 360 m route at constant speed, starting at the same instant as the man and finishing at the same instant as the man.

(ii) Draw a dotted line on your (t, x) graph to represent the woman's journey. [1]

(iii) Calculate the value of t at which the man overtakes the woman. [5]

4 A cyclist travels along a straight road. Her velocity $v\,\mathrm{m\,s^{-1}}$, at time t seconds after starting from a point O, is given by

$$v = 2 \quad \text{for } 0 \leqslant t \leqslant 10,$$
$$v = 0.03t^2 - 0.3t + 2 \quad \text{for } t \geqslant 10.$$

(i) Find the displacement of the cyclist from O when $t = 10$. [1]

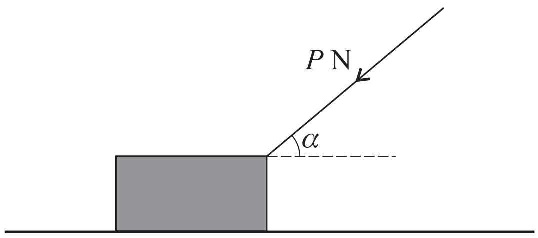
(ii) Show that, for $t \geqslant 10$, the displacement of the cyclist from O is given by the expression $0.01t^3 - 0.15t^2 + 2t + 5$. [4]

(iii) Find the time when the acceleration of the cyclist is $0.6\,\mathrm{m\,s^{-2}}$. Hence find the displacement of the cyclist from O when her acceleration is $0.6\,\mathrm{m\,s^{-2}}$. [5]

5 A block of mass m kg is at rest on a horizontal plane. The coefficient of friction between the block and the plane is 0.2.

(i) When a horizontal force of magnitude 5 N acts on the block, the block is on the point of slipping. Find the value of m. [3]

(ii)



When a force of magnitude P N acts downwards on the block at an angle α to the horizontal, as shown in the diagram, the frictional force on the block has magnitude 6 N and the block is again on the point of slipping. Find

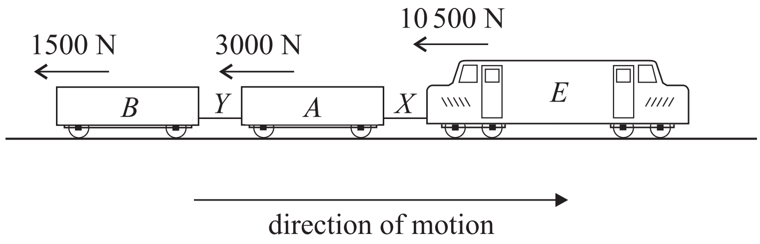
(a) the value of α in degrees,

(b) the value of P.

[8]

[Questions 6 and 7 are printed overleaf.]

6



A train of total mass 80 000 kg consists of an engine E and two trucks A and B. The engine E and truck A are connected by a rigid coupling X, and trucks A and B are connected by another rigid coupling Y. The couplings are light and horizontal. The train is moving along a straight horizontal track. The resistances to motion acting on E, A and B are 10 500 N, 3000 N and 1500 N respectively (see diagram).

(i) By modelling the whole train as a single particle, show that it is decelerating when the driving force of the engine is less than 15 000 N. [2]

(ii) Show that, when the magnitude of the driving force is 35 000 N, the acceleration of the train is $0.25\,\mathrm{m\,s^{-2}}$. [2]

(iii) Hence find the mass of E, given that the tension in the coupling X is 8500 N when the magnitude of the driving force is 35 000 N. [3]

The driving force is replaced by a braking force of magnitude 15 000 N acting on the engine. The force exerted by the coupling Y is zero.

(iv) Find the mass of B. [5]

(v) Show that the coupling X exerts a forward force of magnitude 1500 N on the engine. [2]

7 A particle of mass 0.1 kg is at rest at a point A on a rough plane inclined at 15° to the horizontal. The particle is given an initial velocity of $6\,\mathrm{m\,s^{-1}}$ and starts to move up a line of greatest slope of the plane. The particle comes to instantaneous rest after 1.5 s.

(i) Find the coefficient of friction between the particle and the plane. [7]

(ii) Show that, after coming to instantaneous rest, the particle moves down the plane. [2]

(iii) Find the speed with which the particle passes through A during its downward motion. [6]