

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 $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

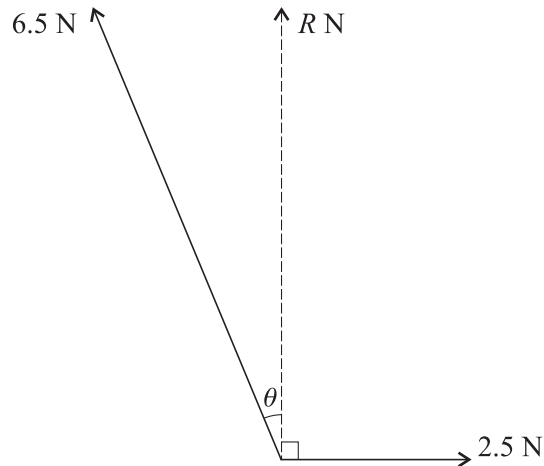
INFORMATION FOR CANDIDATES

- 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 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 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 $\theta = 22.6^\circ$, 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 m s^{-1} , runs the next 180 m at 4.5 m s^{-1} , and then walks the final 60 m at 1.5 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]

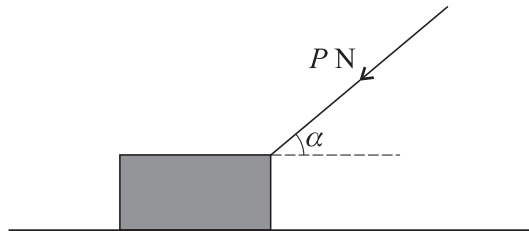
- 4 A cyclist travels along a straight road. Her velocity $v \text{ m s}^{-1}$, at time t seconds after starting from a point O , is given by

$$v = 2 \quad \text{for } 0 \leq t \leq 10,$$

$$v = 0.03t^2 - 0.3t + 2 \quad \text{for } t \geq 10.$$

- (i) Find the displacement of the cyclist from O when $t = 10$. [1]
- (ii) Show that, for $t \geq 10$, 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 m s^{-2} . Hence find the displacement of the cyclist from O when her acceleration is 0.6 m s^{-2} . [5]
- 5 A block of mass $m \text{ kg}$ 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)



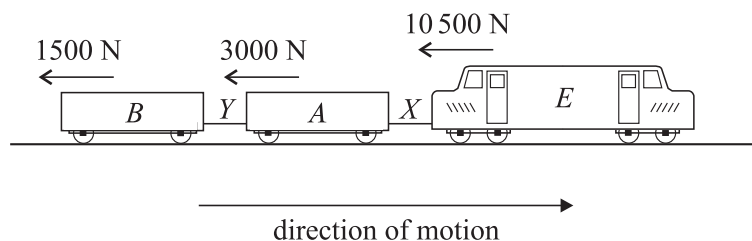
When a force of magnitude $P \text{ N}$ acts downwards on the block at an angle α to the horizontal, as shown in the diagram, the frictional force on the block has magnitude 6 N and the block is again on the point of slipping. Find

- (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 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 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]