

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

**Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education**

MATHEMATICS

4730

Mechanics 3

Tuesday **10 JANUARY 2006** Afternoon 1 hour 30 minutes

Additional materials:
8 page answer booklet
Graph paper
List of Formulae (MF1)

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

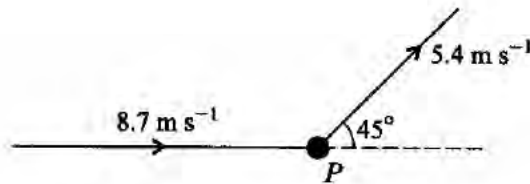
- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration 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



A particle P of mass 0.4 kg moving in a straight line has speed 8.7 m s $^{-1}$. An impulse applied to P deflects it through 45° and reduces its speed to 5.4 m s $^{-1}$ (see diagram). Calculate the magnitude and direction of the impulse exerted on P . [7]

2 O is a fixed point on a horizontal straight line. A particle P of mass 0.5 kg is released from rest at O . At time t seconds after release the only force acting on P has magnitude $(1 + kt^2)$ N and acts horizontally and away from O along the line, where k is a positive constant.

(i) Find the speed of P in terms of k and t . [3]

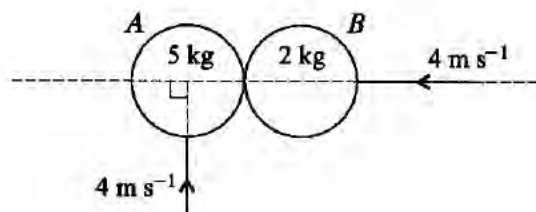
(ii) Given that P is 2 m from O when $t = 1$, find the value of k and the time taken by P to travel 20 m from O . [5]

3 A light elastic string has natural length 3 m. One end is attached to a fixed point O and the other end is attached to a particle of mass 1.6 kg. The particle is released from rest in a position 5 m vertically below O . Air resistance may be neglected.

(i) Given that in the subsequent motion the particle just reaches O , show that the modulus of elasticity of the string is 117.6 N. [4]

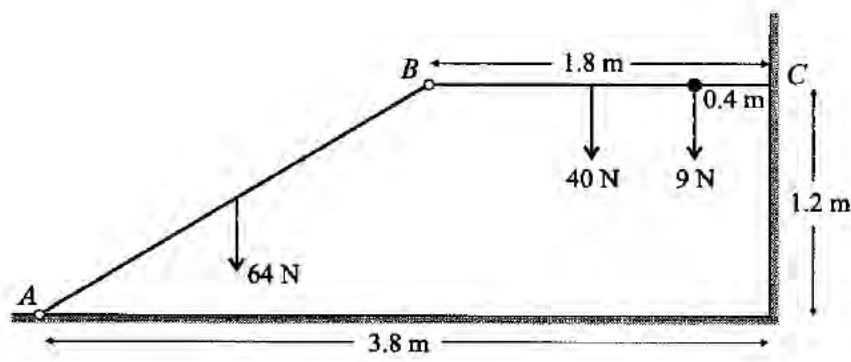
(ii) Calculate the speed of the particle when it is 4.5 m below O . [4]

4



Two uniform smooth spheres A and B , of equal radius, have masses 5 kg and 2 kg respectively. They are moving on a horizontal surface when they collide. Immediately before the collision, A has speed 4 m s $^{-1}$ and is moving perpendicular to the line of centres, and B has speed 4 m s $^{-1}$ along the line of centres (see diagram). The coefficient of restitution is 0.75 . Find the speed and direction of motion of each sphere immediately after the collision. [10]

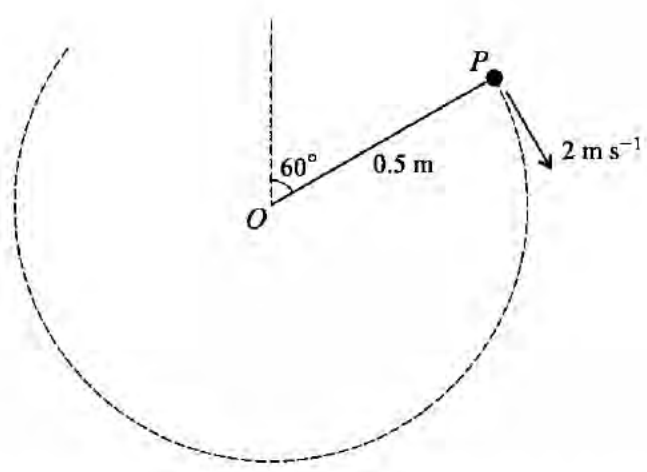
5



Two uniform rods AB and BC have weights 64 N and 40 N respectively. The rods are freely jointed to each other at B . The rod AB is freely jointed to a fixed point on horizontal ground at A and the rod BC rests against a vertical wall at C . The rod BC is 1.8 m long and is horizontal. A particle of weight 9 N is attached to the rod BC at the point 0.4 m from C . The point A is 1.2 m below the level of BC and 3.8 m from the wall (see diagram). The system is in equilibrium.

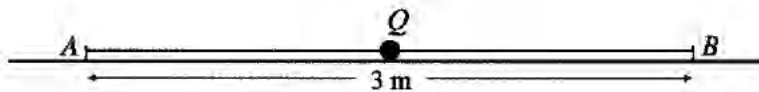
- (i) Show that the magnitude of the frictional force at C is 27 N . [4]
- (ii) Calculate the horizontal and vertical components of the force exerted on AB at B . [5]
- (iii) Given that friction is limiting at C , find the coefficient of friction between the rod BC and the wall. [2]

6



One end of a light inextensible string of length 0.5 m is attached to a fixed point O . A particle P of mass 0.3 kg is attached to the other end of the string. With the string taut and at an angle of 60° to the upward vertical, P is projected with speed 2 m s^{-1} (see diagram). P begins to move without air resistance in a vertical circle with centre O . When the string makes an angle θ with the upward vertical, the speed of P is $v\text{ m s}^{-1}$.

- (i) Show that $v^2 = 8.9 - 9.8 \cos \theta$. [4]
- (ii) Find the tension in the string in terms of θ . [4]
- (iii) P does not move in a complete circle. Calculate the angle through which OP turns before P leaves the circular path. [4]



As shown in the diagram, A and B are fixed points on a smooth horizontal table, where $AB = 3$ m. A particle Q of mass 1.2 kg is attached to A by a light elastic string of natural length 1 m and modulus of elasticity 180 N. Q is attached to B by a light elastic string of natural length 1.2 m and modulus of elasticity 360 N.

(i) Verify that when Q is in equilibrium $BQ = 1.5$ m. [4]

Q is projected towards B from the equilibrium position with speed u m s⁻¹. Subsequently Q oscillates with simple harmonic motion.

(ii) Show that the period of the motion is 0.314 s approximately. [5]

(iii) Show that $u \leq 6$. [4]

(iv) Given that $u = 6$, find the time taken for Q to move from the equilibrium position to a position 1.3 m from A for the first time. [3]