

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

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

MEI STRUCTURED MATHEMATICS

4762

Mechanics 2

Monday **19 JUNE 2006** Morning 1 hour 30 minutes

Additional materials:
8 page answer booklet
Graph paper
MEI Examination Formulae and Tables (MF2)

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.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is 72.

This question paper consists of 6 printed pages and 2 blank pages.

- 1 (a) Two small spheres, P of mass 2 kg and Q of mass 6 kg, are moving in the same straight line along a smooth, horizontal plane with the velocities shown in Fig. 1.1.

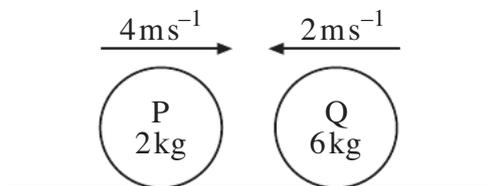


Fig. 1.1

Consider the direct collision of P and Q in the following two cases.

- (i) The spheres coalesce on collision.
- (A) Calculate the common velocity of the spheres after the collision. [3]
- (B) Calculate the energy lost in the collision. [2]
- (ii) The spheres rebound with a coefficient of restitution of $\frac{2}{3}$ in the collision.
- (A) Calculate the velocities of P and Q after the collision. [6]
- (B) Calculate the impulse on P in the collision. [2]
- (b) A small ball bounces off a smooth, horizontal plane. The ball hits the plane with a speed of 26 m s^{-1} at an angle of $\arcsin \frac{12}{13}$ to it. The ball rebounds at an angle of $\arcsin \frac{3}{5}$ to the plane, as shown in Fig. 1.2.

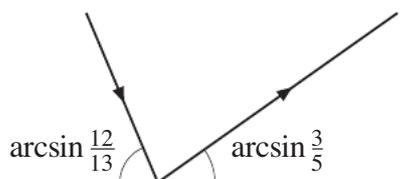


Fig. 1.2

Calculate the speed with which the ball rebounds from the plane.

Calculate also the coefficient of restitution in the impact. [6]

- 2 Two heavy rods AB and BC are freely jointed together at B and to a wall at A. AB has weight 90 N and centre of mass at P; BC has weight 75 N and centre of mass at Q. The lengths of the rods and the positions of P and Q are shown in Fig. 2.1, with the lengths in metres.

Initially, AB and BC are horizontal. There is a support at R, as shown in Fig. 2.1. The system is held in equilibrium by a vertical force acting at C.

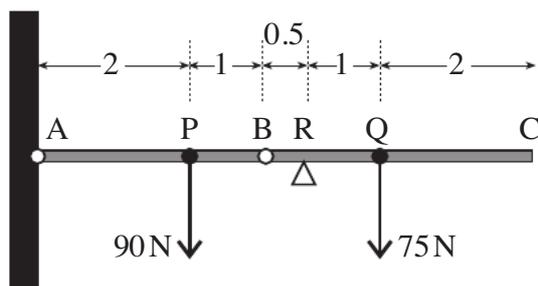


Fig. 2.1

- (i) Draw diagrams showing all the forces acting on rod AB and on rod BC.

Calculate the force exerted on AB by the hinge at B and hence the force required at C. [6]

The rods are now set up as shown in Fig. 2.2. AB and BC are each inclined at 60° to the vertical and C rests on a rough horizontal table. Fig. 2.3 shows all the forces acting on AB, including the forces XN and YN due to the hinge at A and the forces UN and VN in the hinge at B. The rods are in equilibrium.

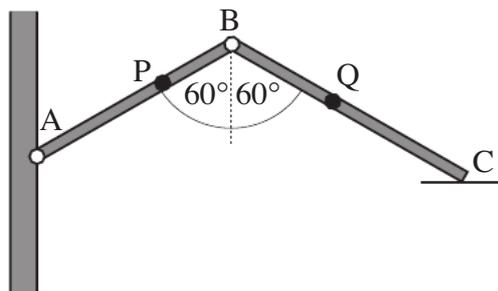


Fig. 2.2

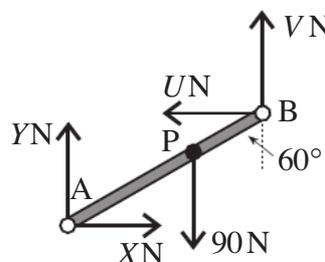


Fig. 2.3

- (ii) By considering the equilibrium of rod AB, show that $60\sqrt{3} = U + V\sqrt{3}$. [3]
- (iii) Draw a diagram showing all the forces acting on rod BC. [1]
- (iv) Find a further equation connecting U and V and hence find their values. Find also the frictional force at C. [8]

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- 3 (a) A car of mass 900 kg is travelling at a steady speed of 16 m s^{-1} up a hill inclined at $\arcsin 0.1$ to the horizontal. The power required to do this is 20 kW.

Calculate the resistance to the motion of the car. [4]

- (b) A small box of mass 11 kg is placed on a uniform rough slope inclined at $\arccos \frac{12}{13}$ to the horizontal. The coefficient of friction between the box and the slope is μ .

(i) Show that if the box stays at rest then $\mu \geq \frac{5}{12}$. [3]

For the remainder of this question, the box moves on a part of the slope where $\mu = 0.2$.

The box is projected up the slope from a point P with an initial speed of $v \text{ m s}^{-1}$. It travels a distance of 1.5 m along the slope before coming instantaneously to rest. During this motion, the work done against air resistance is 6 joules per metre.

(ii) Calculate the value of v . [5]

As the box slides back down the slope, it passes through its point of projection P and later reaches its initial speed at a point Q. During this motion, once again the work done against air resistance is 6 joules per metre.

(iii) Calculate the distance PQ. [6]

[Question 4 is printed overleaf.]

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- 4 Fig. 4.1 shows four uniform rods, OA, AB, BE and CD, rigidly fixed together to form a frame. The rods have weights proportional to their lengths and these lengths, in centimetres, are shown in Fig. 4.1.

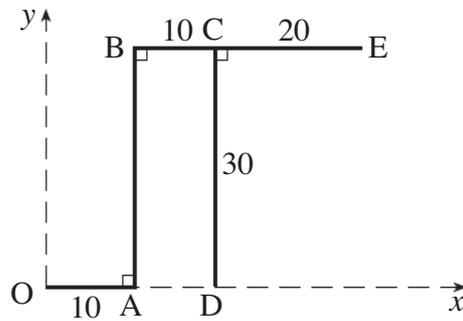


Fig. 4.1

- (i) Calculate the coordinates of the centre of mass of the frame, referred to the axes shown in Fig. 4.1. [5]

The bracket shown in Fig. 4.2 is made of uniform sheet metal with cross-section the frame shown in Fig. 4.1. The bracket is 40 cm wide and its weight is 60 N. It stands on a horizontal plane containing Ox and Oz.

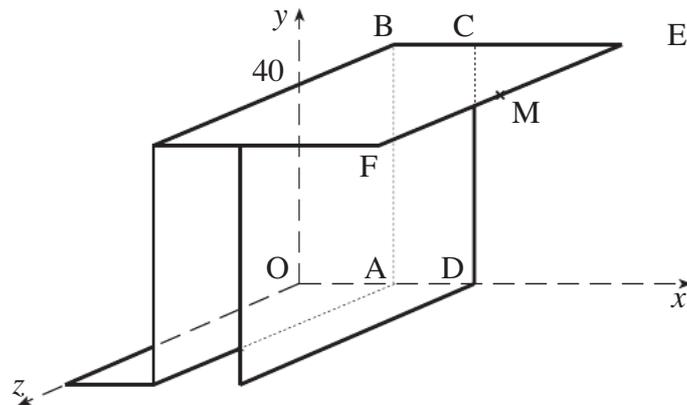


Fig. 4.2

- (ii) Write down the coordinates of the centre of mass of the bracket, referred to the axes shown in Fig. 4.2. [2]

A force PN acts vertically downwards at the point M , shown in Fig. 4.2. M is the mid-point of EF . The bracket is on the point of tipping.

- (iii) Calculate the value of P . [4]

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In another situation, a horizontal force Q N acts through M parallel to EB and in the direction from E to B. The value of Q is increased from zero with the bracket in equilibrium at all times.

- (iv) Draw a diagram showing the forces acting on the bracket when it is on the point of tipping. [1]
- (v) If the limiting frictional force between the bracket and the plane is 30 N, does the bracket slide or tip first as Q is increased? [5]