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1. A particle P moves on the x -axis. At time t seconds, its acceleration is $(5 - 2t) \text{ m s}^{-2}$, measured in the direction of x increasing. When $t = 0$, its velocity is 6 m s^{-1} measured in the direction of x increasing. Find the time when P is instantaneously at rest in the subsequent motion.

(6)

Q1

(Total 6 marks)

3

Turn over



4.

Figure 1

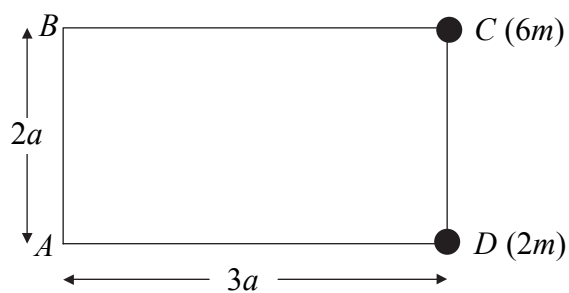


Figure 1 shows four uniform rods joined to form a rigid rectangular framework $ABCD$, where $AB = CD = 2a$, and $BC = AD = 3a$. Each rod has mass m . Particles, of mass $6m$ and $2m$, are attached to the framework at points C and D respectively.

(a) Find the distance of the centre of mass of the loaded framework from

(i) AB ,

(ii) AD .

(7)

The loaded framework is freely suspended from B and hangs in equilibrium.

(b) Find the angle which BC makes with the vertical.

(3)



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5. A vertical cliff is 73.5 m high. Two stones A and B are projected simultaneously. Stone A is projected horizontally from the top of the cliff with speed 28 m s^{-1} . Stone B is projected from the bottom of the cliff with speed 35 m s^{-1} at an angle α above the horizontal. The stones move freely under gravity in the same vertical plane and collide in mid-air. By considering the horizontal motion of each stone,

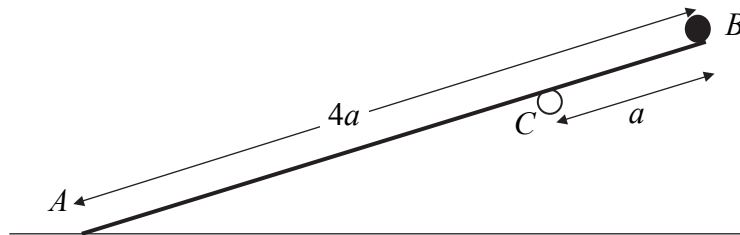
(a) prove that $\cos \alpha = \frac{4}{5}$. (4)

(b) Find the time which elapses between the instant when the stones are projected and the instant when they collide. (4)



6.

Figure 2



A wooden plank AB has mass $4m$ and length $4a$. The end A of the plank lies on rough horizontal ground. A small stone of mass m is attached to the plank at B . The plank is resting on a small smooth horizontal peg C , where $BC = a$, as shown in Figure 2. The plank is in equilibrium making an angle α with the horizontal, where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between the plank and the ground is μ . The plank is modelled as a uniform rod lying in a vertical plane perpendicular to the peg, and the stone as a particle. Show that

(a) the reaction of the peg on the plank has magnitude $\frac{16}{5} mg$, **(3)**

(b) $\mu \geq \frac{48}{61}$. **(6)**

(c) State how you have used the information that the peg is smooth. **(1)**



Question 6 continued

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Q6

(Total 10 marks)



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7. A particle P has mass 4 kg. It is projected from a point A up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between P and the plane is $\frac{2}{7}$. The particle comes to rest instantaneously at the point B on the plane, where $AB = 2.5$ m. It then moves back down the plane to A .

- (a) Find the work done by friction as P moves from A to B . **(4)**
- (b) Using the work-energy principle, find the speed with which P is projected from A . **(4)**
- (c) Find the speed of P when it returns to A . **(4)**



8. Two particles A and B move on a smooth horizontal table. The mass of A is m , and the mass of B is $4m$. Initially A is moving with speed u when it collides directly with B , which is at rest on the table. As a result of the collision, the direction of motion of A is reversed. The coefficient of restitution between the particles is e .

(a) Find expressions for the speed of A and the speed of B immediately after the collision. (7)

In the subsequent motion, B strikes a smooth vertical wall and rebounds. The wall is perpendicular to the direction of motion of B . The coefficient of restitution between B and the wall is $\frac{4}{5}$. Given that there is a second collision between A and B ,

(b) show that $\frac{1}{4} < e < \frac{9}{16}$. (5)

Given that $e = \frac{1}{2}$,

(c) find the total kinetic energy lost in the first collision between A and B . (3)



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Question 8 continued

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Q8

(Total 15 marks)

TOTAL FOR PAPER: 75 MARKS

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