

1. A particle of mass 0.8 kg is moving in a straight line on a rough horizontal plane. The speed of the particle is reduced from 15 m s^{-1} to 10 m s^{-1} as the particle moves 20 m . Assuming that the only resistance to motion is the friction between the particle and the plane, find
- (a) the work done by friction in reducing the speed of the particle from 15 m s^{-1} to 10 m s^{-1} , (2)
- (b) the coefficient of friction between the particle and the plane. (4)



Question 1 continued

Q1

(Total 6 marks)



2. A car of mass 800 kg is moving at a constant speed of 15 m s^{-1} down a straight road inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{24}$. The resistance to motion from non-gravitational forces is modelled as a constant force of magnitude 900 N .

(a) Find, in kW, the rate of working of the engine of the car.

(4)

When the car is travelling down the road at 15 m s^{-1} , the engine is switched off. The car comes to rest in time T seconds after the engine is switched off. The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 900 N .

(b) Find the value of T .

(4)



Question 2 continued

Q2

(Total 8 marks)



3.

Figure 1

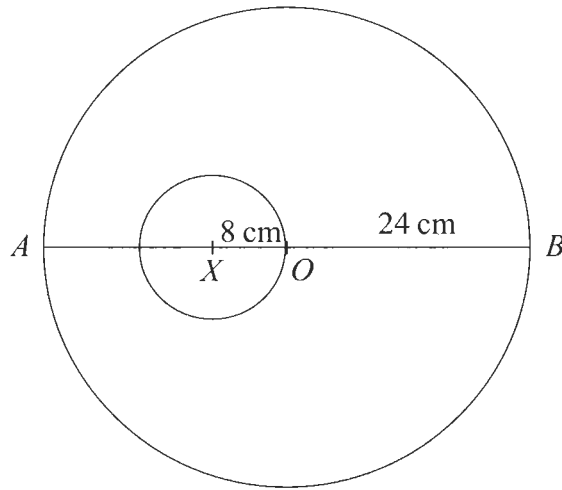


Figure 1 shows a template T made by removing a circular disc, of centre X and radius 8 cm , from a uniform circular lamina, of centre O and radius 24 cm . The point X lies on the diameter AOB of the lamina and $AX = 16\text{ cm}$. The centre of mass of T is at the point G .

(a) Find AG .

(6)

The template T is free to rotate about a smooth fixed horizontal axis, perpendicular to the plane of T , which passes through the mid-point of OB . A small stud of mass $\frac{1}{4}m$ is fixed at B , and T and the stud are in equilibrium with AB horizontal. Modelling the stud as a particle,

(b) find the mass of T in terms of m .

(4)



Leave blank

Question 3 continued

Q3

(Total 10 marks)



4. A particle P of mass m is moving in a straight line on a smooth horizontal table. Another particle Q of mass km is at rest on the table. The particle P collides directly with Q . The direction of motion of P is reversed by the collision. After the collision, the speed of P is v and the speed of Q is $3v$. The coefficient of restitution between P and Q is $\frac{1}{2}$.

(a) Find, in terms of v only, the speed of P before the collision. (3)

(b) Find the value of k . (3)

After being struck by P , the particle Q collides directly with a particle R of mass $11m$ which is at rest on the table. After this second collision, Q and R have the same speed and are moving in opposite directions. Show that

(c) the coefficient of restitution between Q and R is $\frac{3}{4}$, (4)

(d) there will be a further collision between P and Q . (2)



Question 4 continued

Q4

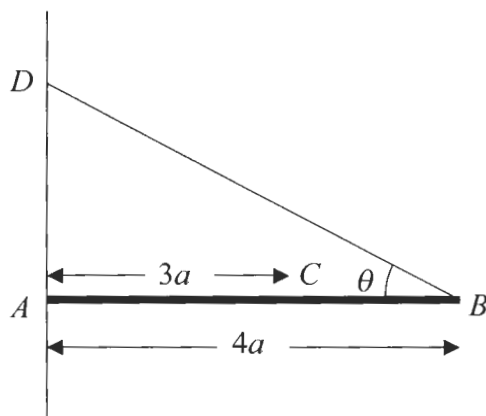
(Total 12 marks)



N 2 3 5 5 9 A 0 9 1 6

5.

Figure 2



A horizontal uniform rod AB has mass m and length $4a$. The end A rests against a rough vertical wall. A particle of mass $2m$ is attached to the rod at the point C , where $AC = 3a$. One end of a light inextensible string BD is attached to the rod at B and the other end is attached to the wall at a point D , where D is vertically above A . The rod is in equilibrium in a vertical plane perpendicular to the wall. The string is inclined at an angle θ to the horizontal, where $\tan \theta = \frac{3}{4}$, as shown in Figure 2.

- (a) Find the tension in the string. (5)
- (b) Show that the horizontal component of the force exerted by the wall on the rod has magnitude $\frac{8}{3}mg$. (3)

The coefficient of friction between the wall and the rod is μ . Given that the rod is in limiting equilibrium,

- (c) find the value of μ . (4)



Question 5 continued

Q5

(Total 12 marks)



N 2 3 5 5 9 A 0 1 1 1 6

6. A particle P of mass 0.5 kg is moving under the action of a single force \mathbf{F} newtons. At time t seconds, $\mathbf{F} = (1.5t^2 - 3)\mathbf{i} + 2t\mathbf{j}$. When $t = 2$, the velocity of P is $(-4\mathbf{i} + 5\mathbf{j}) \text{ m s}^{-1}$.

(a) Find the acceleration of P at time t seconds. (2)

(b) Show that, when $t = 3$, the velocity of P is $(9\mathbf{i} + 15\mathbf{j}) \text{ m s}^{-1}$. (5)

When $t = 3$, the particle P receives an impulse \mathbf{Q} N s. Immediately after the impulse the velocity of P is $(-3\mathbf{i} + 20\mathbf{j}) \text{ m s}^{-1}$. Find

(c) the magnitude of \mathbf{Q} , (3)

(d) the angle between \mathbf{Q} and \mathbf{i} . (3)



Question 6 continued

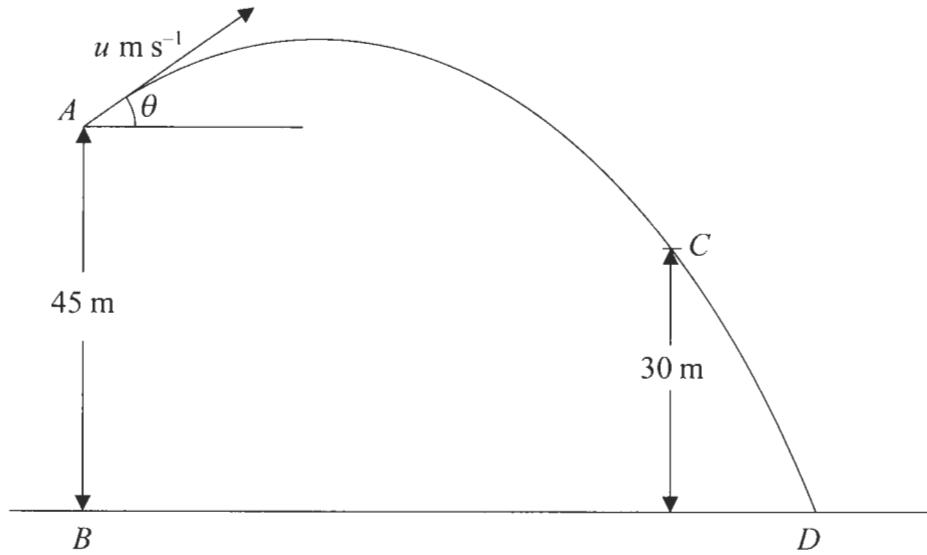
Q6

(Total 13 marks)



7.

Figure 3



A particle P is projected from a point A with speed $u\text{ m s}^{-1}$ at an angle of elevation θ , where $\cos\theta = \frac{4}{5}$. The point B , on horizontal ground, is vertically below A and $AB = 45\text{ m}$. After projection, P moves freely under gravity passing through a point C , 30 m above the ground, before striking the ground at the point D , as shown in Figure 3.

Given that P passes through C with speed 24.5 m s^{-1} ,

(a) using conservation of energy, or otherwise, show that $u = 17.5$, (4)

(b) find the size of the angle which the velocity of P makes with the horizontal as P passes through C , (3)

(c) find the distance BD . (7)



Question 7 continued



Question 7 continued

Q7

(Total 14 marks)

TOTAL FOR PAPER: 75 MARKS

END

