

QQQ – Further Mechanics 2 – Chapter 3 – Further Centres of Mass (Version 1)

Total Marks: 24

(24 = Platinum, 22 = Gold, 19 = Silver, 16 = Bronze)

1. A uniform solid is formed by rotating the region enclosed between the curve with equation $y = \sqrt{x}$, the x -axis and the line $x = 4$, through one complete revolution about the x -axis. Find the distance of the centre of mass of the solid from the origin O . **(5)**

(Total 5 marks)

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2.

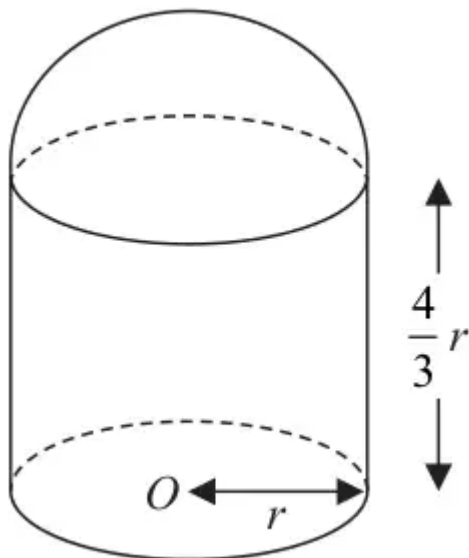


Figure 3

A uniform solid cylinder of base radius r and height $\frac{4}{3}r$ has the same density as a uniform solid hemisphere of radius r . The plane face of the hemisphere is joined to a plane face of the cylinder to form the composite solid S shown in Figure 3. The point O is the centre of the plane face of S .

- (a) Show that the distance from O to the centre of mass of S is $\frac{73}{72}r$. (4)

The solid S is placed with its plane face on a rough horizontal plane. The coefficient of friction between S and the plane is μ . A horizontal force P is applied to the highest point of S . The magnitude of P is gradually increased.

- (b) Find the range of values of μ for which S will slide before it starts to tilt. (5)

(Total 9 marks)

3.

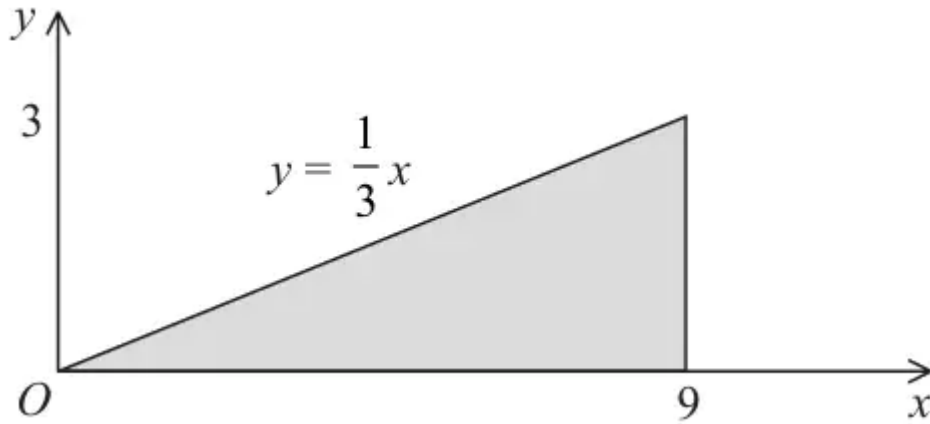


Figure 4

The shaded region shown in Figure 4 is bounded by the x -axis, the line with equation $x = 9$ and the line with equation $y = \frac{1}{3}x$. This shaded region is rotated through 360° about the x -axis to form a solid of revolution. This solid of revolution is used to model a solid right circular cone of height 9 cm and base radius 3 cm.

The cone is non-uniform and the mass per unit volume of the cone at the point (x, y, z) is $\lambda x \text{ kg cm}^{-3}$, where $0 \leq x \leq 9$ and λ is constant.

(a) Find the distance of the centre of mass of the cone from its vertex. (6)

A toy is made by joining the circular plane face of the cone to the circular plane face of a uniform solid hemisphere of radius 3 cm, so that the centres of the two plane surfaces coincide.

The weight of the cone is W newtons and the weight of the hemisphere is kW newtons.

When the toy is placed on a smooth horizontal plane with any point of the curved surface of the hemisphere in contact with the plane, the toy will remain at rest.

(b) Find the value of k (4)

(Total 10 marks)