

Equilibrium of a Rigid Body

Question Paper 2

Level	International A Level
Subject	Maths
Exam Board	CIE
Topic	Equilibrium of a Rigid Body
Sub Topic	
Booklet	Question Paper 2

Time Allowed: 57 minutes

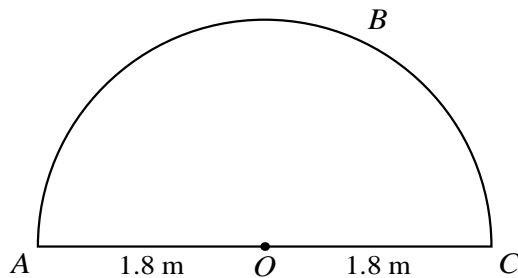
Score: /47

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1



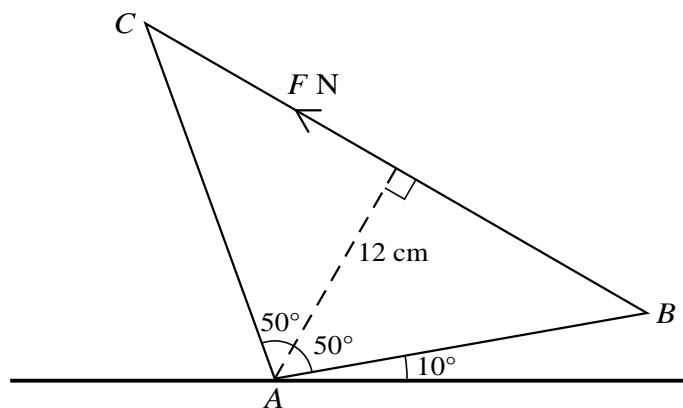
A uniform metal frame $OABC$ is made from a semicircular arc ABC of radius 1.8 m, and a straight rod AOC with $AO = OC = 1.8$ m (see diagram).

(i) Calculate the distance of the centre of mass of the frame from O . [3]

A uniform semicircular lamina of radius 1.8 m has weight 27.5 N. A non-uniform object is formed by attaching the frame $OABC$ around the perimeter of the lamina. The object is freely suspended from a fixed point at A and hangs in equilibrium. The diameter AOC of the object makes an angle of 22° with the vertical.

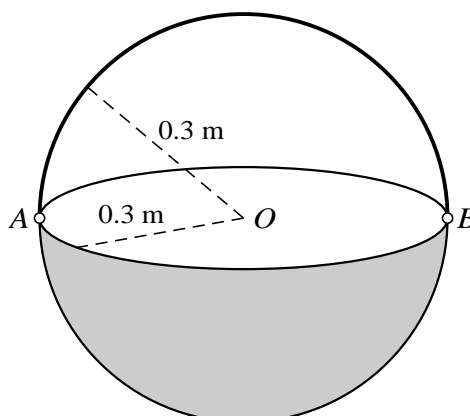
(ii) Calculate the weight of the frame. [5]

2



A uniform lamina ABC in the shape of an isosceles triangle has weight 24 N. The perpendicular distance from A to BC is 12 cm. The lamina rests in a vertical plane in equilibrium, with the vertex A in contact with a horizontal surface. Angle $BAC = 100^\circ$ and AB makes an angle of 10° with the horizontal. Equilibrium is maintained by a force of magnitude F N acting along BC (see diagram). Show that $F = 8$. [3]

3



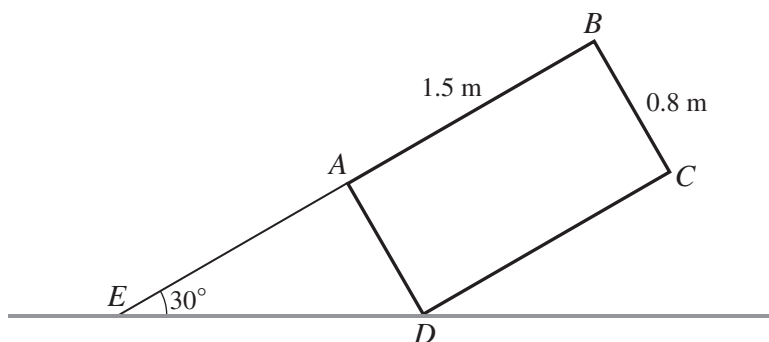
The diagram shows a container which consists of a bowl of weight 14 N and a handle of weight 8 N. The bowl of the container is in the form of a uniform hemispherical shell with centre O and radius 0.3 m. The handle is in the form of a uniform semicircular arc of radius 0.3 m and is freely hinged to the bowl at A and B , where AB is a diameter of the bowl.

- (i) Calculate the distance of the centre of mass of the container from O for the position indicated in the diagram, where the handle is perpendicular to the rim of the bowl. [3]
- (ii) Show that the distance of the centre of mass of the container from O when the handle lies on the rim of the bowl is 0.118 m, correct to 3 significant figures. [5]

In the case when the handle lies on the rim of the bowl, the container rests in equilibrium with the curved surface of the bowl on a horizontal table.

- (iii) Find the angle which the plane containing the rim of the bowl makes with the horizontal. [2]

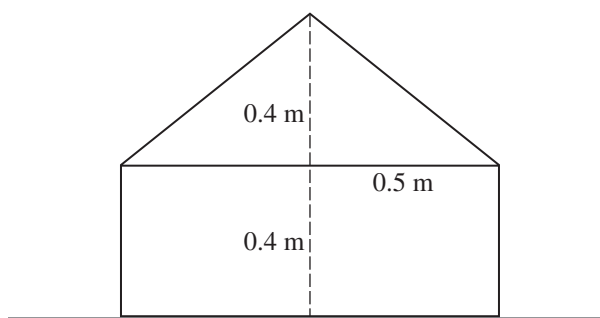
4



$ABCD$ is the cross-section through the centre of mass of a uniform rectangular block of weight 260 N. The lengths AB and BC are 1.5 m and 0.8 m respectively. The block rests in equilibrium with the point D on a rough horizontal floor. Equilibrium is maintained by a light rope attached to the point A on the block and the point E on the floor. The points E , A and B lie in a straight line inclined at 30° to the horizontal (see diagram).

- (i) By taking moments about D , show that the tension in the rope is 146 N, correct to 3 significant figures. [5]
- (ii) Given that the block is in limiting equilibrium, calculate the coefficient of friction between the block and the floor. [4]

5



A uniform solid is made from a cylinder and a cone, both with radius 0.5 m and height 0.4 m. The circular base of the cone is attached to a circular face of the cylinder, with their circumferences coinciding. The solid rests in equilibrium with the circular face of the solid on a rough horizontal surface (see diagram).

(i) Show that the centre of mass of the solid is 0.275 m above the surface. [3]

The weight of the solid is 60 N. A horizontal force of increasing magnitude P N is applied to the vertex of the cone which causes the solid eventually to topple without sliding.

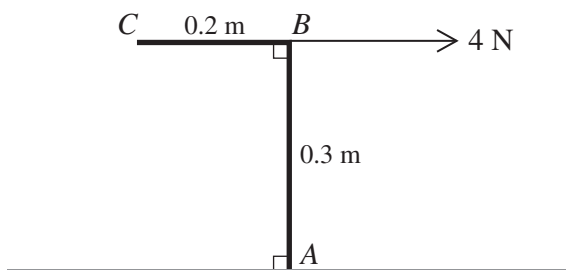
(ii) Calculate the value of P for which the solid is on the point of toppling. [2]

(iii) Find the least possible value for the coefficient of friction between the solid and the surface. [1]

The force of magnitude P N is removed, and the solid is held with the curved surface of the cylinder in contact with the horizontal surface. The horizontal surface is then tilted so that it makes an angle of 30° with the horizontal. The solid is released, with its axis of symmetry parallel to a line of greatest slope and the conical portion pointing down the slope.

(iv) Show that the solid does not slide, but does topple. [4]

6



A uniform object ABC is formed from two rods AB and BC joined rigidly at right angles at B . The rod AB has length 0.3 m and the rod BC has length 0.2 m. The object rests with the end A on a rough horizontal surface and the rod AB vertical. The object is held in equilibrium by a horizontal force of magnitude 4 N applied at B and acting in the direction CB (see diagram).

- (i) Find the distance of the centre of mass of the object from AB . [3]
- (ii) Calculate the weight of the object. [2]
- (iii) Find the least possible value of the coefficient of friction between the surface and the object. [2]