Equilibrium of a Rigid Body

Question Paper 8

Level	International A Level
Subject	Maths
Exam Board	CIE
Topic	Equilibrium of a Rigid Body
Sub Topic	
Booklet	Question Paper 8

Time Allowed: **57 minutes**

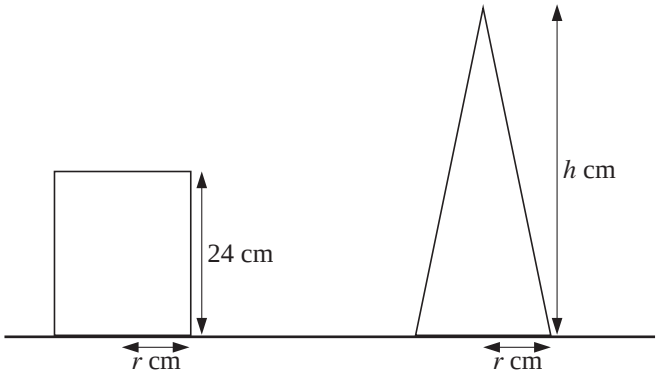
Score: **/47**

Percentage: **/100**

Grade Boundaries:

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

1

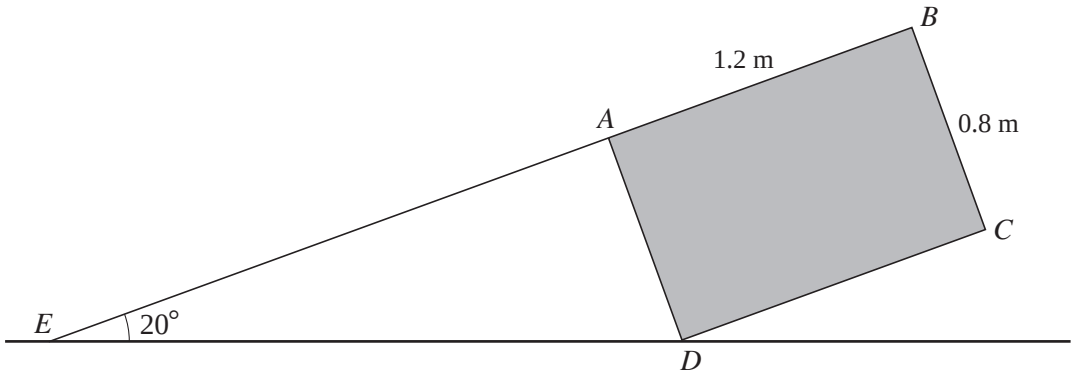


A uniform solid cylinder has height 24 cm and radius r cm. A uniform solid cone has base radius r cm and height h cm. The cylinder and the cone are both placed with their axes vertical on a rough horizontal plane (see diagram, which shows cross-sections of the solids). The plane is slowly tilted and both solids remain in equilibrium until the angle of inclination of the plane reaches $\alpha°$, when both solids topple simultaneously.

(i) Find the value of h. [2]

(ii) Given that $r = 10$, find the value of α. [2]

2

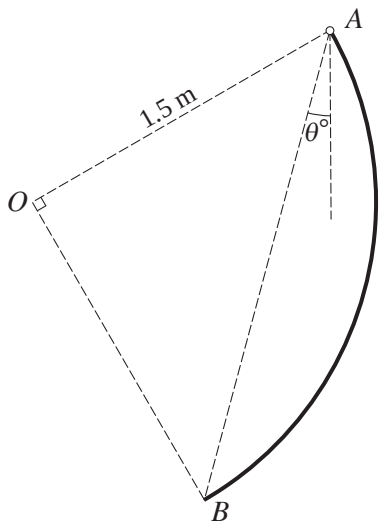


ABCD is a central cross-section of a uniform rectangular block of mass 35 kg. The lengths of *AB* and *BC* are 1.2 m and 0.8 m respectively. The block is held in equilibrium by a rope, one end of which is attached to the point *E* of a rough horizontal floor. The other end of the rope is attached to the block at *A*. The rope is in the same vertical plane as *ABCD*, and *EAB* is a straight line making an angle of 20° with the horizontal (see diagram).

(i) Show that the tension in the rope is 187 N, correct to the nearest whole number. [5]

(ii) The block is on the point of slipping. Find the coefficient of friction between the block and the floor. [4]

3

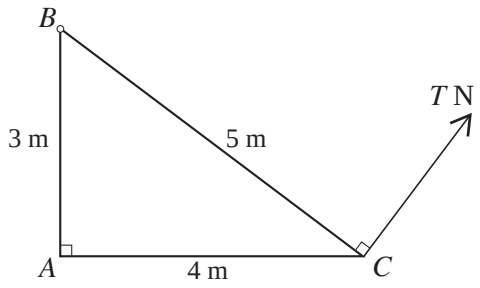


A uniform rigid wire AB is in the form of a circular arc of radius 1.5 m with centre O. The angle AOB is a right angle. The wire is in equilibrium, freely suspended from the end A. The chord AB makes an angle of $\theta°$ with the vertical (see diagram).

(i) Show that the distance of the centre of mass of the arc from O is 1.35 m, correct to 3 significant figures. [2]

(ii) Find the value of θ. [3]

4



Uniform rods AB, AC and BC have lengths 3 m, 4 m and 5 m respectively, and weights 15 N, 20 N and 25 N respectively. The rods are rigidly joined to form a right-angled triangular frame ABC. The frame is hinged at B to a fixed point and is held in equilibrium, with AC horizontal, by means of an inextensible string attached at C. The string is at right angles to BC and the tension in the string is T N (see diagram).

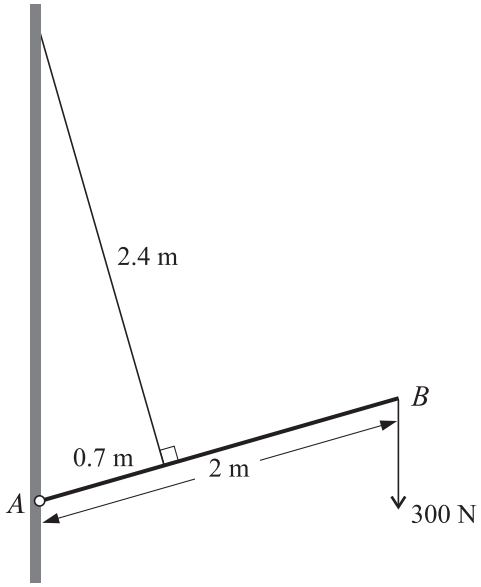
(i) Find the value of T. [2]

A uniform triangular lamina PQR, of weight 60 N, has the same size and shape as the frame ABC. The lamina is now attached to the frame with P, Q and R at A, B and C respectively. The composite body is held in equilibrium with A, B and C in the same positions as before. Find

(ii) the new value of T, [2]

(iii) the magnitude of the vertical component of the force acting on the composite body at B. [2]

5



A uniform beam AB has length 2 m and mass 10 kg. The beam is hinged at A to a fixed point on a vertical wall, and is held in a fixed position by a light inextensible string of length 2.4 m. One end of the string is attached to the beam at a point 0.7 m from A. The other end of the string is attached to the wall at a point vertically above the hinge. The string is at right angles to AB. The beam carries a load of weight 300 N at B (see diagram).

(i) Find the tension in the string. [4]

The components of the force exerted by the hinge on the beam are X N horizontally away from the wall and Y N vertically downwards.

(ii) Find the values of X and Y. [3]

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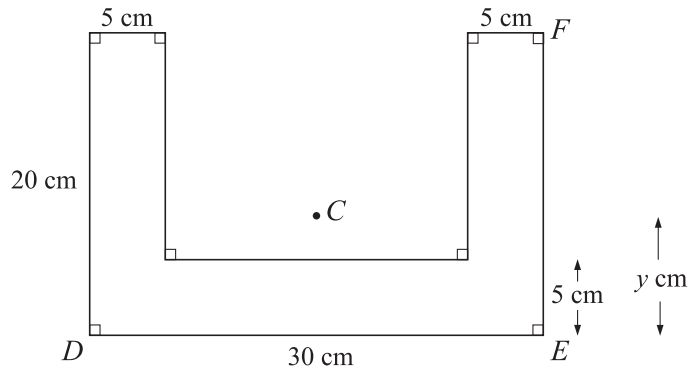


Fig. 1

Fig. 1 shows the cross-section of a uniform solid. The cross-section has the shape and dimensions shown. The centre of mass C of the solid lies in the plane of this cross-section. The distance of C from DE is y cm.

(i) Find the value of y. [3]

The solid is placed on a rough plane. The coefficient of friction between the solid and the plane is μ. The plane is tilted so that EF lies along a line of greatest slope.

(ii)

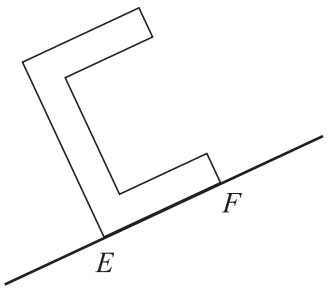


Fig. 2

The solid is placed so that F is higher up the plane than E (see Fig. 2). When the angle of inclination is sufficiently great the solid starts to topple (without sliding). Show that $\mu > \frac{1}{2}$. [3]

(iii)

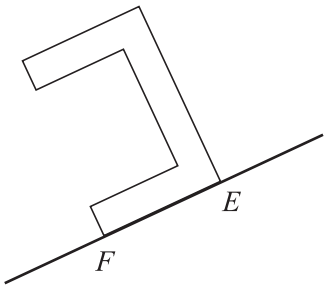
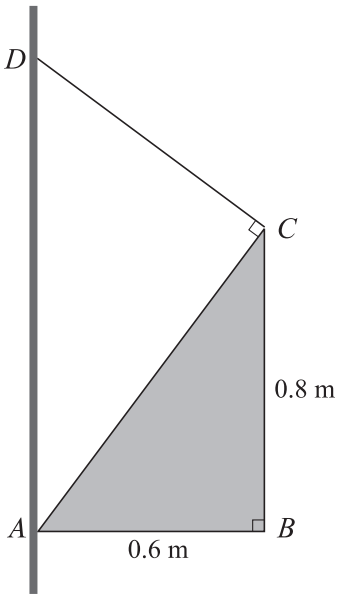


Fig. 3

The solid is now placed so that E is higher up the plane than F (see Fig. 3). When the angle of inclination is sufficiently great the solid starts to slide (without toppling). Show that $\mu < \frac{5}{6}$. [3]

7



A uniform triangular lamina ABC is right-angled at B and has sides $AB = 0.6$ m and $BC = 0.8$ m. The mass of the lamina is 4 kg. One end of a light inextensible rope is attached to the lamina at C. The other end of the rope is attached to a fixed point D on a vertical wall. The lamina is in equilibrium with A in contact with the wall at a point vertically below D. The lamina is in a vertical plane perpendicular to the wall, and AB is horizontal. The rope is taut and at right angles to AC (see diagram). Find

(i) the tension in the rope, [4]

(ii) the horizontal and vertical components of the force exerted at A on the lamina by the wall. [3]