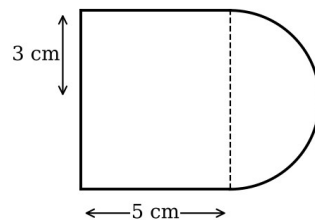


3E Toppling and Sliding

If a body rests in equilibrium on a rough inclined plane, the line of action of the weight:

What happens if the line of action of the weight passes outside the face in contact with the plane?

1. A solid uniform cylinder of radius 3 cm and height 5 cm has a solid uniform hemisphere made from the same material, of radius 3 cm, joined to it so that the base of the hemisphere coincides with one circular end of the cylinder.



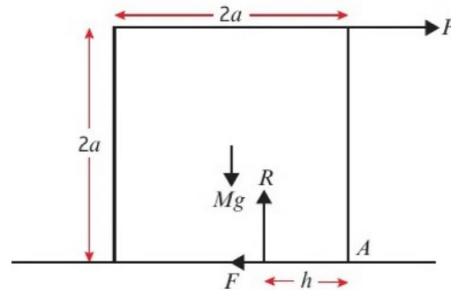
- a) Find the position of the centre of mass of the composite body.

	Mass	Ratio of masses	Height of centre of mass above base (cm)
Cylinder			
Hemisphere			
Composite body			

The composite body is placed with the circular face of the cylinder on a rough inclined plane, which is inclined at an angle α to the horizontal. Given that the plane is sufficiently rough to prevent sliding,

- b) show that equilibrium is maintained provided that $\tan \alpha < \frac{28}{33}$.

2. A uniform solid cube of mass M and side $2a$ rests on a rough horizontal plane. The coefficient of friction is μ . A horizontal force of magnitude P is applied at the midpoint of an upper edge, perpendicular to that edge, as shown in the diagram. The reaction between the plane and the cube comprises a normal reaction force R and a friction force F and acts at a distance h from a lower edge of the cube as shown in the diagram.



Find whether the cube remains in equilibrium, or whether the equilibrium is broken by sliding or toppling, in each of the following cases. Also determine the value of F and the value of h in each case, giving your answers in terms of M , g and a as appropriate:

a) $P = 0$

b) $P = \frac{1}{2}Mg$ and $\mu = \frac{3}{4}$

c) $P = \frac{1}{4}Mg$ and $\mu = \frac{1}{5}$

A body is on the point of sliding when:

A body is on the point of toppling when:

3. A uniform solid cube of mass M and side $2a$ is placed on a rough inclined plane which is at an angle α to the horizontal, where $\tan \alpha = \frac{1}{2}$. The coefficient of friction is μ . Show that if $\mu < \frac{1}{2}$ the cube will slide down the slope.
4. The cube in the previous example is now replaced by a cylinder of mass M with base radius a and height $6a$. The cylinder is placed on the rough inclined plane, which is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{1}{2}$. The coefficient of friction is μ . Show that if $\mu > \frac{1}{2}$ the cylinder will topple about the lower edge.