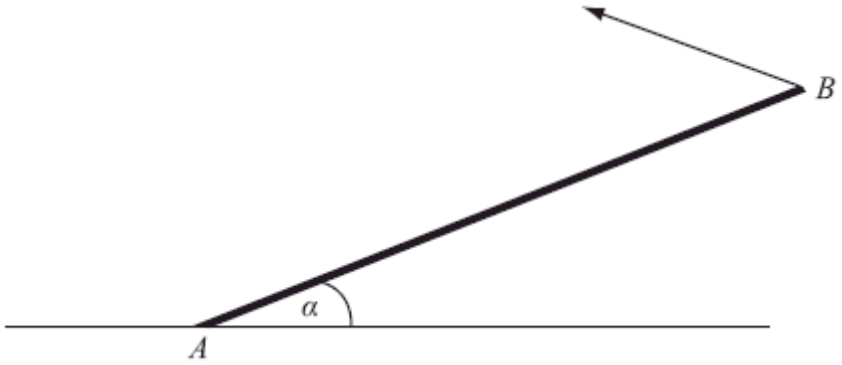
Year 2 Applied Chapter 7: Statics of Rigid Bodies
Exam Questions (Total Marks 67)

1.

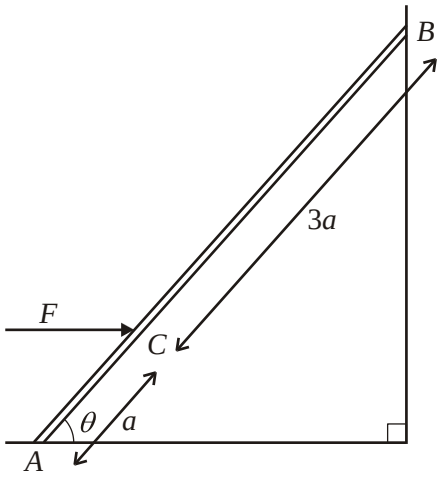


A uniform rod *AB*, of mass 20 kg and length 4 m, rests with one end *A* on rough horizontal ground. The rod is held in limiting equilibrium at an angle α to the horizontal, where tan $\alpha = \frac{3}{4}$, by a force acting at *B*, as shown in Figure 2. The line of action of this force lies in the vertical plane which contains the rod. The coefficient of friction between the ground and the rod is 0.5.

Find the magnitude of the normal reaction of the ground on the rod at *A*.

(Total 7 marks)

2.

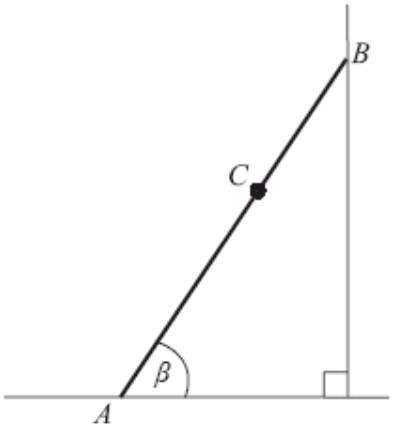


A uniform ladder AB has one end A on smooth horizontal ground. The other end B rests against a smooth vertical wall. The ladder is modelled as a uniform rod of mass m and length $4a$. The ladder is kept in equilibrium by a horizontal force F acting at a point C of the ladder where $AC = a$. The force F and the ladder lie in a vertical plane perpendicular to the wall. The ladder is inclined to the horizontal at an angle θ, where $\tan\theta = 2$, as shown in the diagram above.

Find F in terms of m and g.

(Total 6 marks)

3.



The diagram above shows a ladder AB, of mass 25 kg and length 4 m, resting in equilibrium with one end A on rough horizontal ground and the other end B against a smooth vertical wall. The ladder is in a vertical plane perpendicular to the wall. The coefficient of friction between the ladder and the ground is. $\frac{11}{25}$ The ladder makes an angle β with the ground. When Reece, who has mass 75 kg, stands at the point C on the ladder, where AC = 2.8 m, the ladder is on the point of slipping. The ladder is modelled as a uniform rod and Reece is modelled as a particle.

(a) Find the magnitude of the frictional force of the ground on the ladder.

(3)

(b) Find, to the nearest degree, the value of β.

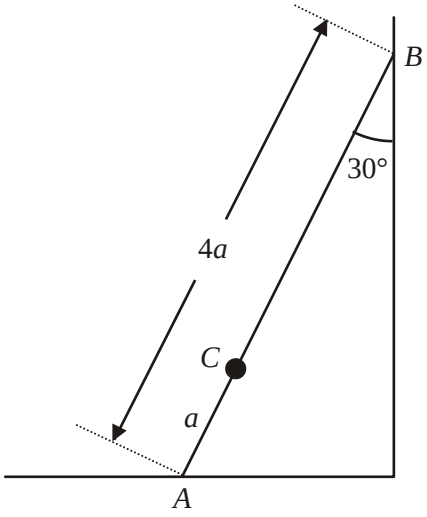
(6)

(c) State how you have used the modelling assumption that Reece is a particle.

(1)

(Total 10 marks)

4.

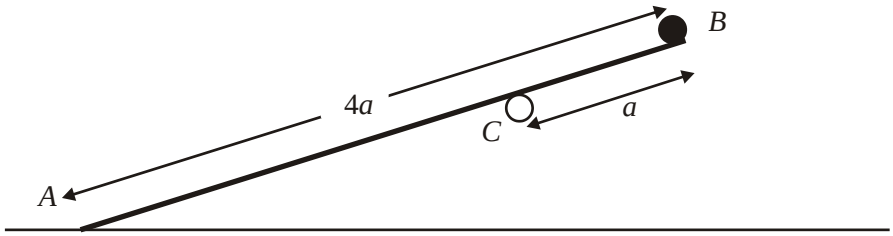


A ladder *AB*, of mass *m* and length 4*a*, has one end *A* resting on rough horizontal ground. The other end *B* rests against a smooth vertical wall. A load of mass 3*m* is fixed on the ladder at the point *C*, where *AC* = *a*. The ladder is modelled as a uniform rod in a vertical plane perpendicular to the wall and the load is modelled as a particle. The ladder rests in limiting equilibrium making an angle of 30° with the wall, as shown in the diagram above.

Find the coefficient of friction between the ladder and the ground.

(Total 10 marks)

5.



A wooden plank AB has mass $4m$ and length $4a$. The end A of the plank lies on rough horizontal ground. A small stone of mass m is attached to the plank at B. The plank is resting on a small smooth horizontal peg C, where $BC = a$, as shown in the figure above. The plank is in equilibrium making an angle α with the horizontal, where $\tan\alpha = \frac{3}{4}$. The coefficient of friction between the plank and the ground is μ. The plank is modelled as a uniform rod lying in a vertical plane perpendicular to the peg, and the stone as a particle.

Show that

(a) the reaction of the peg on the plank has magnitude $\frac{16}{5}mg$,

(3)

(b) $\mu \geq \frac{48}{61}$

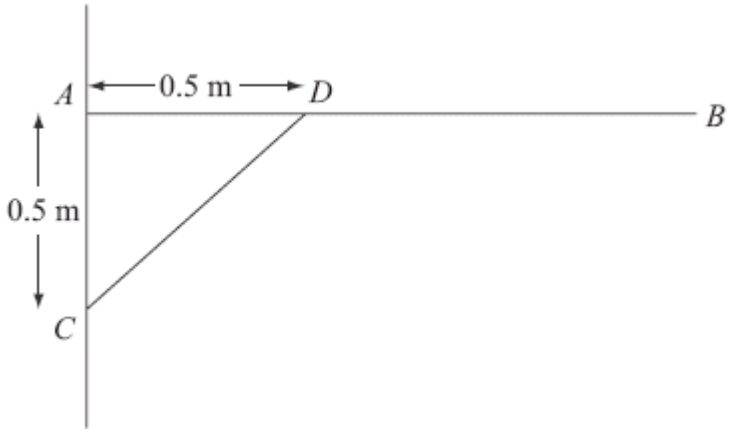
(6)

(c) State how you have used the information that the peg is smooth.

(1)

(Total 10 marks)

6.



A uniform rod *AB*, of length 1.5 m and mass 3 kg, is smoothly hinged to a vertical wall at *A*. The rod is held in equilibrium in a horizontal position by a light strut *CD* as shown in the diagram above. The rod and the strut lie in the same vertical plane, which is perpendicular to the wall. The end *C* of the strut is freely jointed to the wall at a point 0.5 m vertically below *A*. The end *D* is freely joined to the rod so that *AD* is 0.5 m.

(a) Find the thrust in *CD*.

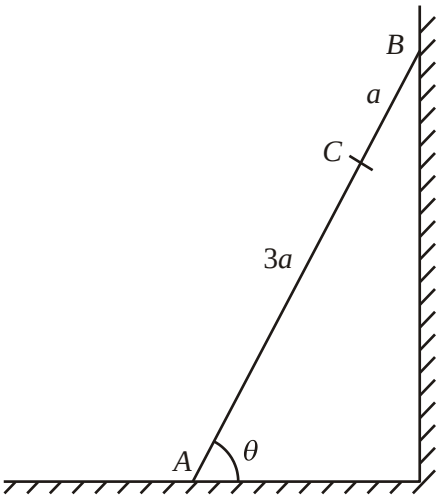
(4)

(b) Find the magnitude and direction of the force exerted on the rod *AB* at *A*.

(7)

(Total 11 marks)

7.



A ladder AB, of weight W and length $4a$, has one end A on rough horizontal ground. The coefficient of friction between the ladder and the ground is μ. The other end B rests against a smooth vertical wall. The ladder makes an angle θ with the horizontal, where $\tan\theta = 2$. A load of weight $4W$ is placed at the point C on the ladder, where $AC = 3a$, as shown in the figure above. The ladder is modelled as a uniform rod which is in a vertical plane perpendicular to the wall. The load is modelled as a particle. Given that the system is in limiting equilibrium,

(a) show that $\mu = 0.35$.

(6)

A second load of weight kW is now placed on the ladder at A. The load of weight $4W$ is removed from C and placed on the ladder at B. The ladder is modelled as a uniform rod which is in a vertical plane perpendicular to the wall. The loads are modelled as particles. Given that the ladder and the loads are in equilibrium,

(b) find the range of possible values of k.

(7)

(Total 13 marks)