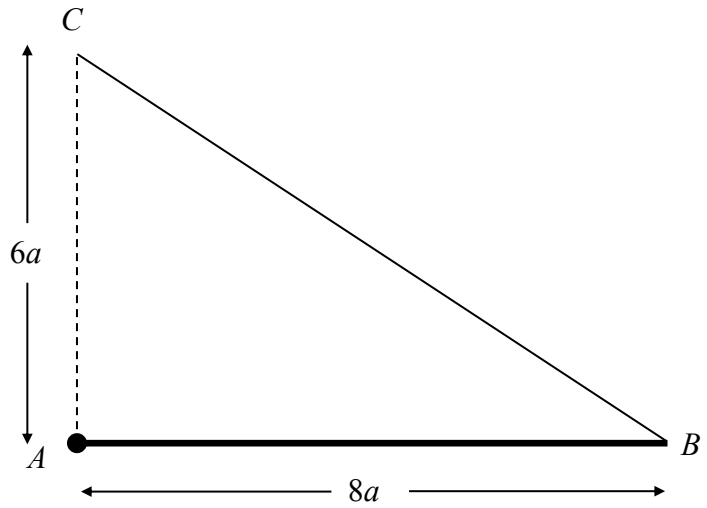
Static Rigid Bodies - Edexcel Past Exam Questions

1. **Figure 1**



A uniform rod AB, of length $8a$ and weight W, is free to rotate in a vertical plane about a smooth pivot at A. One end of a light inextensible string is attached to B. The other end is attached to point C which is vertically above A, with $AC = 6a$. The rod is in equilibrium with AB horizontal, as shown in Figure 1.

(a) By taking moments about A, or otherwise, show that the tension in the string is $\frac{5}{6}W$.

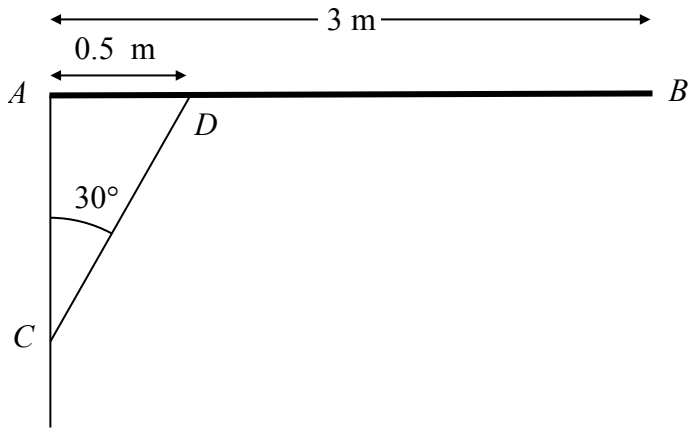
(4)

(b) Calculate the magnitude of the horizontal component of the force exerted by the pivot on the rod.

(3)

Jan 05 Q1

2. **Figure 2**



A uniform pole AB, of mass 30 kg and length 3 m, is smoothly hinged to a vertical wall at one end A. The pole is held in equilibrium in a horizontal position by a light rod CD. One end C of the rod is fixed to the wall vertically below A. The other end D is freely jointed to the pole so that $\angle ACD = 30°$ and $AD = 0.5$ m, as shown in Figure 2. Find

(a) the thrust in the rod CD, **(4)**

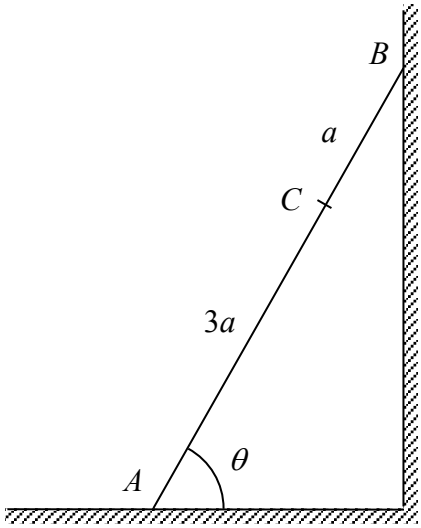
(b) the magnitude of the force exerted by the wall on the pole at A. **(6)**

The rod CD is removed and replaced by a longer light rod CM, where M is the mid-point of AB. The rod is freely jointed to the pole at M. The pole AB remains in equilibrium in a horizontal position.

(c) Show that the force exerted by the wall on the pole at A now acts horizontally. **(2)**

June 05 Q6

3. **Figure 2**



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 Figure 2. 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,

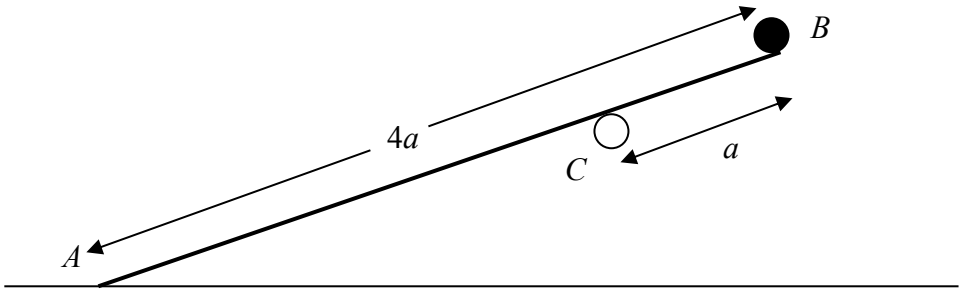
(a) show that $\mu = 0.35$. **(6)**

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)**

Jan 06 Q6

4. **Figure 2**



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 Figure 2. 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

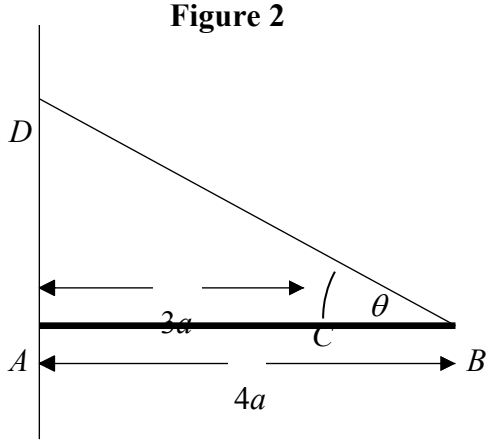
(a) the reaction of the peg on the plank has magnitude $\frac{16}{5}\ mg$, **(3)**

(b) $\mu \geq \frac{48}{61}$. **(6)**

(c) State how you have used the information that the peg is smooth. **(1)**

June 06 Q6

5. **Figure 2**



A horizontal uniform rod AB has mass m and length $4a$. The end A rests against a rough vertical wall. A particle of mass $2m$ is attached to the rod at the point C, where $AC = 3a$. One end of a light inextensible string BD is attached to the rod at B and the other end is attached to the wall at a point D, where D is vertically above A. The rod is in equilibrium in a vertical plane perpendicular to the wall. The string is inclined at an angle θ to the horizontal, where $\tan\theta = \frac{3}{4}$, as shown in Figure 2.

(a) Find the tension in the string. **(5)**

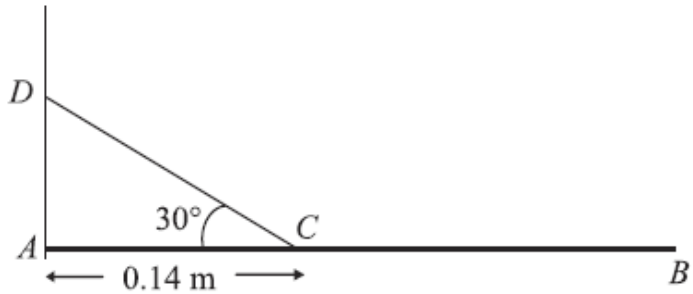
(b) Show that the horizontal component of the force exerted by the wall on the rod has magnitude $\frac{8}{3}mg$. **(3)**

The coefficient of friction between the wall and the rod is μ. Given that the rod is in limiting equilibrium,

(c) find the value of μ. **(4)**

Jan 07 Q5

6. **Figure 3**



A uniform beam AB of mass 2 kg is freely hinged at one end A to a vertical wall. The beam is held in equilibrium in a horizontal position by a rope which is attached to a point C on the beam, where $AC = 0.14$ m. The rope is attached to the point D on the wall vertically above A, where $\angle ACD = 30°$, as shown in Figure 3. The beam is modelled as a uniform rod and the rope as a light inextensible string. The tension in the rope is 63 N.

Find

(*a*) the length of AB, **(4)**

(*b*) the magnitude of the resultant reaction of the hinge on the beam at A. **(5)**

June 07 Q5

7.

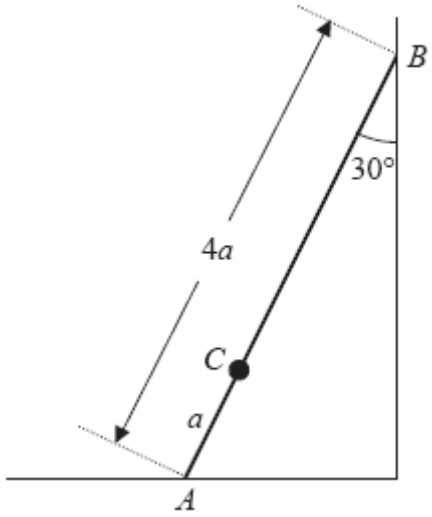


Figure 2

A ladder AB, of mass m and length $4a$, has one end A resting on rough horizontal ground. The other end B rests against a smooth vertical wall. A load of mass $3m$ 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 Figure 2.

Find the coefficient of friction between the ladder and the ground. **(10)**

Jan 08 Q5

8.

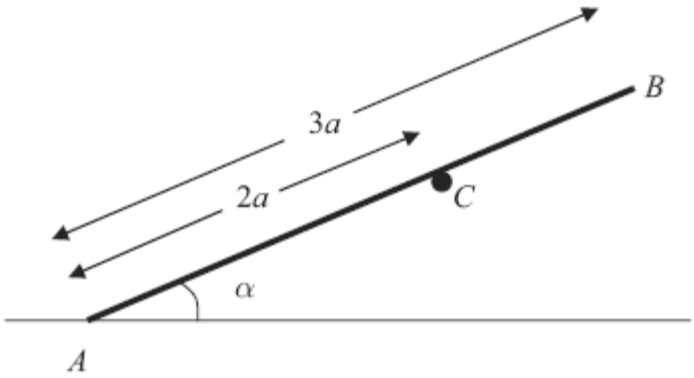


Figure 2

A plank rests in equilibrium against a fixed horizontal pole. The plank is modelled as a uniform rod AB and the pole as a smooth horizontal peg perpendicular to the vertical plane containing AB. The rod has length $3a$ and weight W and rests on the peg at C, where $AC = 2a$. The end A of the rod rests on rough horizontal ground and AB makes an angle α with the ground, as shown in Figure 2.

(a) Show that the normal reaction on the rod at A is $\frac{1}{4}(4 - 3\cos^2\alpha)W$. **(6)**

Given that the rod is in limiting equilibrium and that $\cos\alpha = \frac{2}{3}$,

(b) find the coefficient of friction between the rod and the ground. **(5)**

June 08 Q5

9.

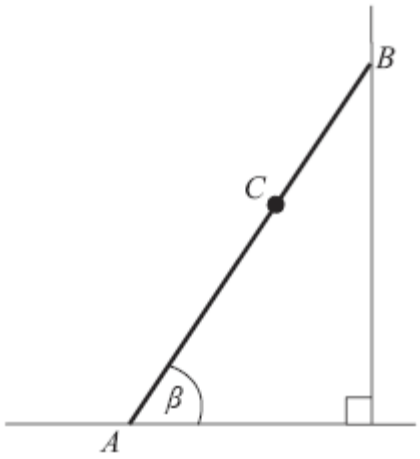


Figure 1

Figure 1 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)**

Jan 09 Q2

10.

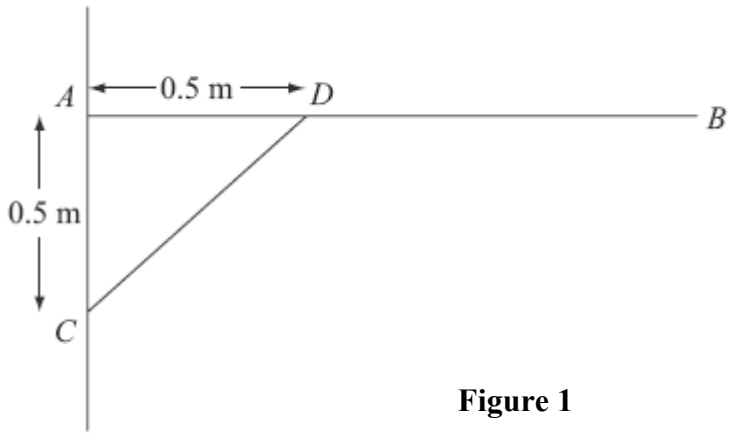


Figure 1

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 Figure 1. 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)**

June 09 Q4

11.

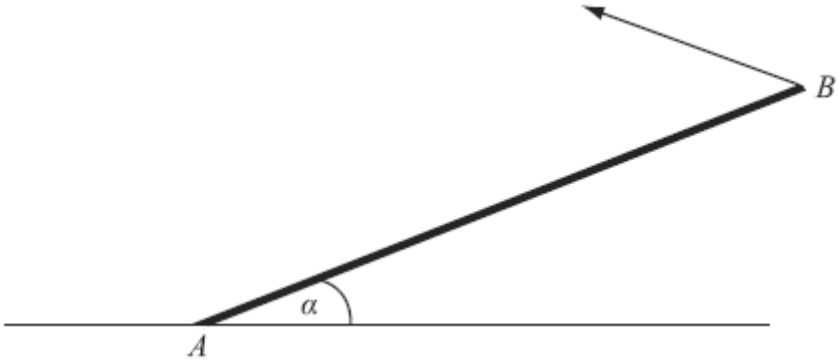


Figure 2

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. **(7)**

Jan 10 Q6

12.

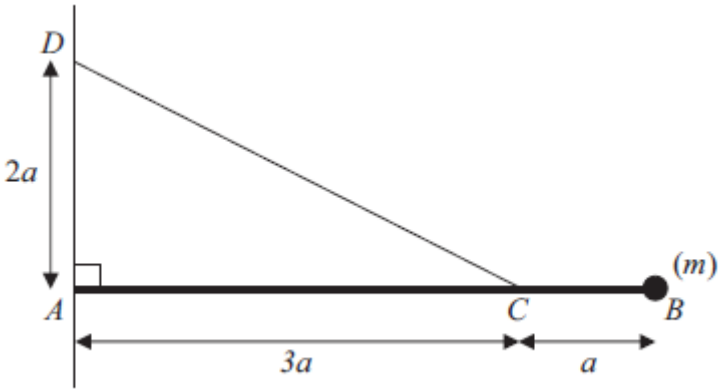


Figure 2

Figure 2 shows a uniform rod AB of mass m and length $4a$. The end A of the rod is freely hinged to a point on a vertical wall. A particle of mass m is attached to the rod at B. One end of a light inextensible string is attached to the rod at C, where $AC = 3a$. The other end of the string is attached to the wall at D, where $AD = 2a$ and D is vertically above A. The rod rests horizontally in equilibrium in a vertical plane perpendicular to the wall and the tension in the string is T.

(a) Show that $T = mg\sqrt{13}$. **(5)**

The particle of mass m at B is removed from the rod and replaced by a particle of mass M which is attached to the rod at B. The string breaks if the tension exceeds $2mg\sqrt{13}$. Given that the string does not break,

(b) show that $M \leq \frac{5}{2}m$. **(3)**

June 10 Q6

13.

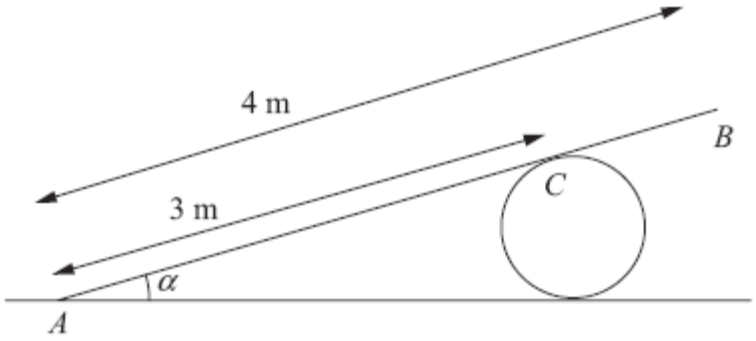


Figure 4

A uniform plank AB, of weight 100 N and length 4 m, rests in equilibrium with the end A on rough horizontal ground. The plank rests on a smooth cylindrical drum. The drum is fixed to the ground and cannot move. The point of contact between the plank and the drum is C, where $AC = 3$ m, as shown in Figure 4. The plank is resting in a vertical plane which is perpendicular to the axis of the drum, at an angle α to the horizontal, where $\sin \alpha = \frac{1}{3}$. The coefficient of friction between the plank and the ground is μ.

Modelling the plank as a rod, find the least possible value of μ. **(10)**

Jan 11 Q7

14.

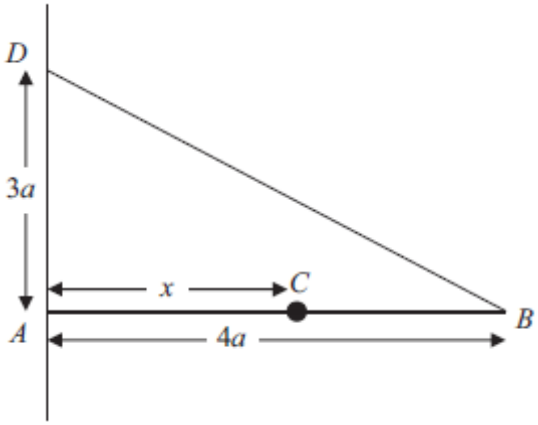


Figure 3

A uniform rod AB, of mass $3m$ and length $4a$, is held in a horizontal position with the end A against a rough vertical wall. One end of a light inextensible string BD is attached to the rod at B and the other end of the string is attached to the wall at the point D vertically above A, where $AD = 3a$. A particle of mass $3m$ is attached to the rod at C, where $AC = x$. The rod is in equilibrium in a vertical plane perpendicular to the wall as shown in Figure 3. The tension in the string is $\frac{25}{4}mg$.

Show that

(a) $x = 3a$, **(5)**

(b) the horizontal component of the force exerted by the wall on the rod has magnitude $5mg$. **(3)**

The coefficient of friction between the wall and the rod is μ. Given that the rod is about to slip,

(c) find the value of μ. **(5)**

June 11 Q7