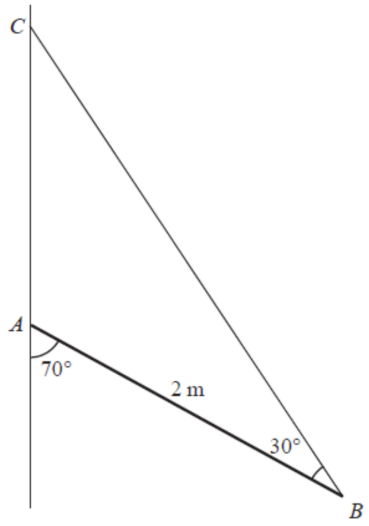
Question 1:



A uniform rod AB has mass 6 kg and length 2 m. The end A of the rod rests against a rough vertical wall. The rod is held in limiting equilibrium by the string BC.

(a) Find the tension in the string.

[4]

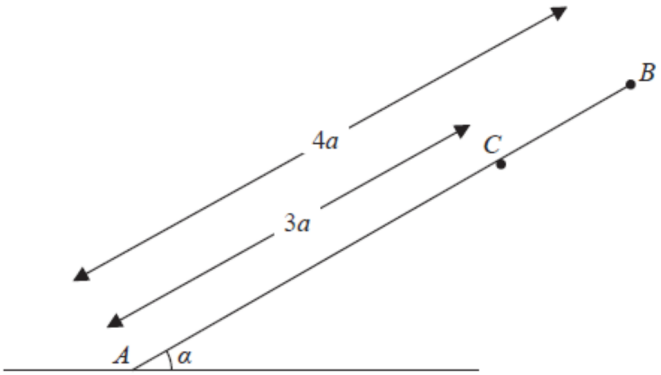
(b) Find the coefficient of friction between the rod and the wall.

[5]

(c) Find the direction of the force exerted on the rod by the wall at A.

[2]

Question 2:



A uniform rod AB has length $4a$ and weight W. A particle of weight kW, $k < 1$, is attached to the rod at B. The rod rests in equilibrium against a fixed smooth peg. The end A of the rod is on rough horizontal ground. It is given that $\tan\alpha = \frac{1}{3}$.

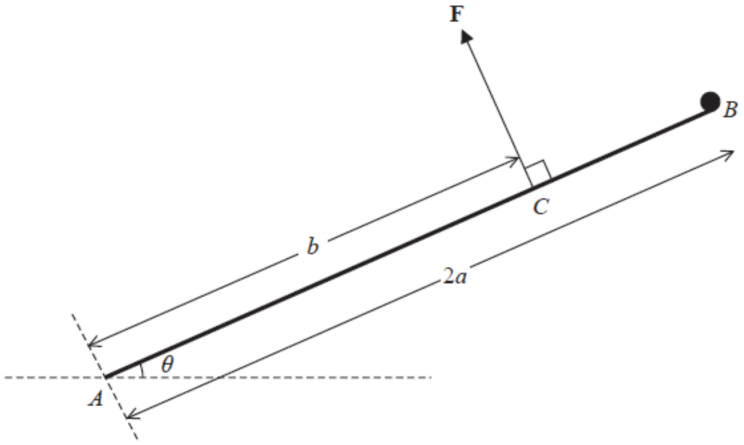
(a) Find, in terms of k and W, the magnitude of the force acting on the rod at C.

[4]

(b) Given that the coefficient of friction between the rod and the ground is $\frac{3}{4}$, show that $k \leq \frac{2}{11}$ for the rod to remain in equilibrium.

[7]

Question 3:



A uniform rod AB, of mass $3m$ and length $2a$, is freely hinged at A. A particle of mass m is attached to the rod at the end B. The system is held in equilibrium by a force $\mathbf{F}$ acting at the point C.

(a) Show that the magnitude of $\mathbf{F}$ is $\dfrac{5mga}{b}\cos\theta$.

[4]

The force exerted on the rod by the hinge at A is $\mathbf{R}$, which acts upwards at an angle ϕ above the horizontal, where $\phi > \theta$.

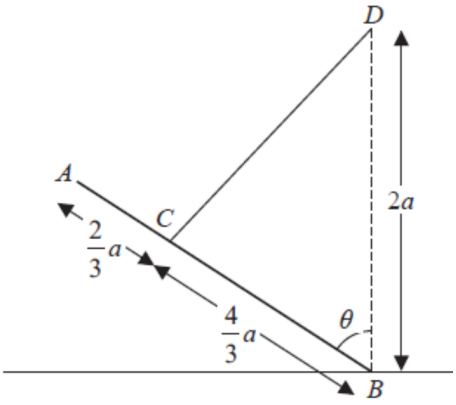
(b) Find, in terms of a, b, m, g, and θ, the component of $\mathbf{R}$ that is parallel to the rod, and the component of $\mathbf{R}$ that is perpendicular to the rod.

[5]

(c) Hence, or otherwise, find the range of possible values of b, giving your answer in terms of a.

[2]

Question 4:



A uniform rod AB of mass m and length 2a rests with the end B on rough horizontal ground. The rod is held in equilibrium at an angle θ to the vertical by a light inextensible string. One end of the string is attached to the rod at the point C, where $AC = \frac{2}{3}a$. The other end of the string is attached to the point D, which is vertically above B, where $BD = 2a$.

(a) Find the magnitude of the frictional force acting on the rod at B.

[3]

(b) Find the magnitude of the normal reaction on the rod at B.

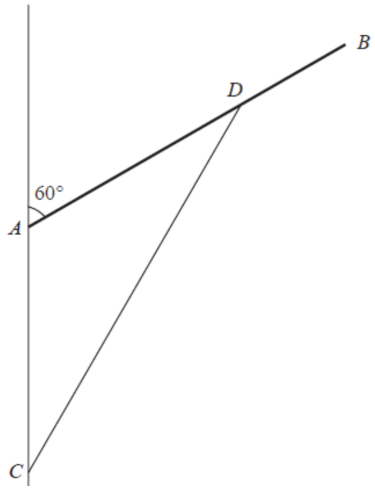
[5]

The rod is in limiting equilibrium when $\tan\theta = \frac{4}{3}$.

(c) Find the coefficient of friction between the rod and the ground.

[3]

Question 5:



A uniform rod AB of weight W is freely hinged at end A to a vertical wall. The rod is supported in equilibrium at an angle of $60°$ to the wall by a light rigid strut CD. The strut is freely hinged to the rod at the point D and to the wall at the point C, which is vertically below A. The length of the rod is $4a$ and $AC = AD = 2.5a$.

(a) Find, in terms of W, the magnitude of the thrust in the strut.

[3]

(b) Find the magnitude of the force acting on the rod at A.

[6]

Numerical Answers:

(1) (a) $T = 55$ N
(b) $\mu = 0.464$
(c) $65.1°$ from the upward vertical

(2) (a) $R_C = \dfrac{\sqrt{10}}{5}W(1 + 2k)$
(b) $k \leq \dfrac{2}{11}$

(3) (a) $|\mathbf{F}| = \dfrac{5mga}{b}\cos\theta$
(b) $R_{\text{parallel}} = 4mg\sin\theta$, $R_{\text{perpendicular}} = 4mg\cos\theta - \dfrac{5mga}{b}\cos\theta$
(c) $b > \dfrac{5}{4}a$

(4) (a) $F = \dfrac{1}{2}mg\sin\theta$
(b) $R = \dfrac{1}{4}mg(1 + 2\cos\theta)$
(c) $\mu = \dfrac{8}{11}$

(5) (a) $T = \dfrac{4}{5}\sqrt{3}W$
(b) $F = \dfrac{\sqrt{13}}{5}W$