Godalming College

Mechanics 9 – Static Rigid Bodies

Please **complete** this homework by _____. Start it early. If you can't do a question you will then have time to ask your teacher for help or go to a drop in session.

Section 1 – Review of previous topics.
Please complete all questions.

1. A plank AB has mass 12 kg and length 2.4 m. A load of mass 8 kg is attached to the plank at the point C, where $AC = 0.8$ m. The loaded plank is held in equilibrium, with AB horizontal, by two vertical ropes, one attached at A and the other attached at B, as shown in Figure 1. The plank is modelled as a uniform rod, the load as a particle and the ropes as light inextensible strings.

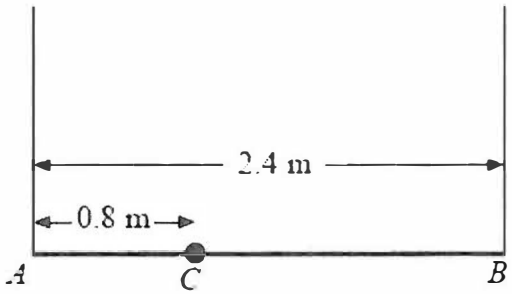

Figure 1

a) Find the tension in the rope attached at B **(4)**

b) The plank is now modelled as a non-uniform rod. With the new model, the tension in the rope attached at A is 10 N greater than the tension in the rope attached at B. Find the distance of the centre of mass of the plank from A. **(6)**

2. Using data from Camborne, Heathrow, Leuchars, Hurn and Leeming in 1987, the average daily total hours of sunshine during June in the UK is modelled by a Normal distribution with mean 4.38 hours and variance 14.0 hours^2. The sunshine levels are measured in those locations during June 2015 to see whether it was a particularly sunny month by comparison.

a) State null and alternative hypotheses for this test.

The 150 daily readings have an average of 6.76 hours.

b) Calculate the test statistic and the critical value if the test is the 5% level.

c) State with a reason whether the null hypothesis is accepted or rejected. Determine, in context, the conclusion of the hypothesis test.

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Section 2 – Consolidation of this week's topic.
Please complete all questions.

1) A uniform ladder, of mass 15kg and length 4m, is placed with its base on rough horizontal ground. The coefficient of friction between the ladder and the ground is ⅓. The upper end of the ladder rests against a smooth vertical wall, the ladder making an angle α with the horizontal.

   a) On a diagram, clearly label all the forces which act on the ladder. **(4)**
   b) Find, in terms of α, the moment of the weight about the base of the ladder, stating the sense and the units. **(3)**
   c) Find the minimum value of α such that the ladder does not slip. **(4)**

2) A uniform ladder, of length 2.4m and mass 10kg, rests against a smooth vertical wall and its lower end is on rough horizontal ground. The ladder is inclined at 70° to the horizontal. A girl of mass 60 kg can climb to a point on the ladder which is 1.8m away from the foot of the ladder.

   a) Find the minimum possible value of the coefficient of friction between the ladder and the ground. **(4)**
   b) A friend of the girl then puts her foot on the base of the ladder and applies a vertical force. Find what force she must apply to enable her friend to reach the top of the ladder. **(5)**

3)

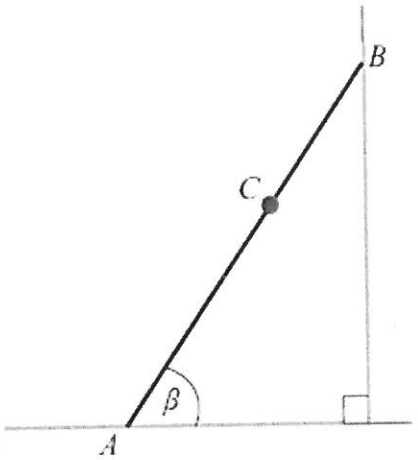

Figure 2

Figure 2 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)

4)

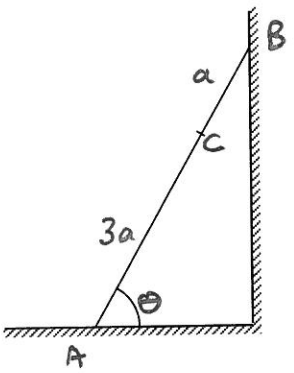

Figure 3

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 3. 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)**

5)

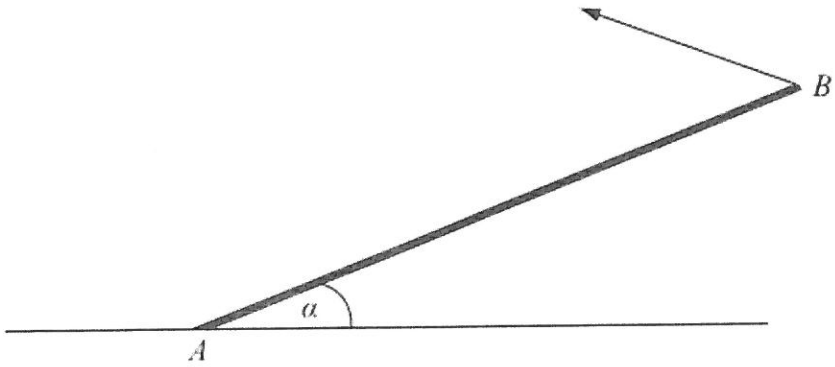

Figure 3

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 3. 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)

Total mark: 50