5.6 PROBLEMS

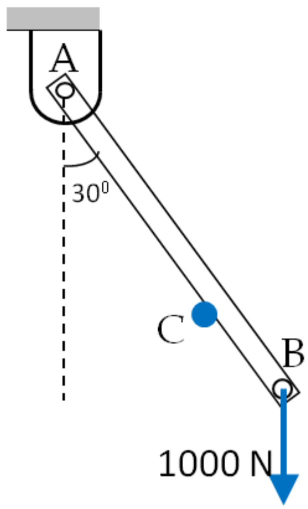

Figure 5.17: Problem 5.6.1.

Problem 5.6.1. Rod AB of mass 30 kg and length 1 m is supported by a pin at A and rests on a frictionless peg at C at a distance of 70 cm from A. A force of 1000 N is applied at B as shown. Find the forces on the rod at A and C.

Ans: With x horizontal and y vertical, A_x = -662 N, A_y = 912 N; C_x = 662 N, C_y = 382 N.

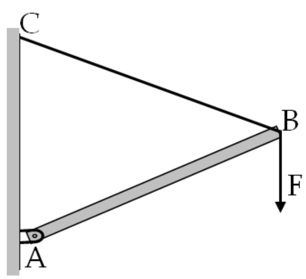

Figure 5.18: Problem 5.6.2.

Problem 5.6.2. A vertical force is applied at the end B of the bar AB of mass M and length L that is hinged at A and supported by a steel cable of cross-sectional area A attached to the wall at C. Find the percent change in length of the cable if the Young's modulus of steel is Y, distance AC is $\frac{3}{4}$L, and the angle ∠CAB equal θ.

Ans: $\frac{\Delta L}{L} = \frac{1}{Y}\frac{T}{A}$ with $T = \frac{(2F+Mg)\tan\theta}{2\cos\psi}$.

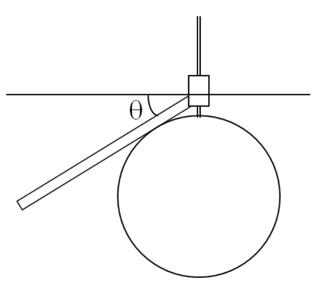

Figure 5.19: Problem 5.6.3

Problem 5.6.3. A thin rod of mass M and length L rests on a cylinder of radius R. The rod is attached to a collar of negligible mass,which is free to slide without friction over a vertical guide. Find angle θ at which the rod must rest so that the collar does not slide.

Ans Key: For $L = 50$ cm and $R = 20$ cm, $\theta = 38°$.

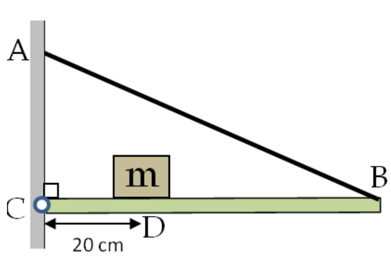

Figure 5.20: Problem 5.6.4.

Problem 5.6.4. A steel cable AB of diameter $D = 1$ mm supports a beam CB of mass $M = 2$ kg and length $L = 60$ cm hinged at C as shown in the Figure. Assuming the length of the cable to be 65 cm, find the tension in the cable and the force on the pin if a mass $m = 200$ kg is placed on the beam at a distance $d = 20$ cm from the pin. First try solving the problem in symbols and then plug in the numbers.

Ans: Symbolically, the magnitude of tension $T = \dfrac{L_c}{L_b\sqrt{L_c^2 - L_b^2}} \times (mgd + MgL_b/2)$, Numerical values: T = 1730 N, C_x = 1590 N, C_y = 1320 N.

Problem 5.6.5. A M = 200-kg motorcycle is parked on a slope facing uphill. As a result the normal force on the rear wheel is greater than on the front wheel. If the slope is greater than $\theta = 40°$, the motorcycle slides on the slope. The distance between the front and back wheels is $d = 1.2$ meters and the CM of the motorcycle is halfway between the two wheels and $h = 30$ cm from the ground as measured in the vertical direction from the slope. The coefficients of static friction between the wheels and the ground are same for both wheels. Find the normal forces on front and rear wheels when it parked at the maximum slope before sliding.

Hint: There are five forces on the motorcycle, Mg, N_1, N_2, F_{s1}, and F_{s2}. Answer in symbol for $N_{1,2} = \left(\frac{1}{2} \pm \frac{h}{d}\sin\theta\right) \times Mg\cos\theta$.

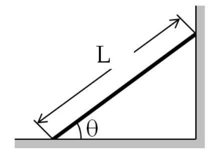

Figure 5.22: Problem 5.6.6.

Problem 5.6.6. A board of mass m and length L is resting against a vertical wall. The coefficient of static friction between the board and the wall and between the board and the floor are μ_w and μ_f, respectively. Find the minimum angle θ the board may be placed without slipping.

Ans: $\tan\theta = \dfrac{1}{2\mu_f} - \dfrac{\mu_w}{2}$.

Problem 5.6.7. A spherical ball of mass M and radius R is resting against a step of height h (h¡R). A horizontal force $\vec{F}$ is applied to the ball so that its line of action always passes through the center of the ball, as shown in the figure. Find the minimum force needed to make the ball climb over the step.

Ans Hint: If $h = \dfrac{R}{2}$, then $F = \sqrt{5}Mg$.

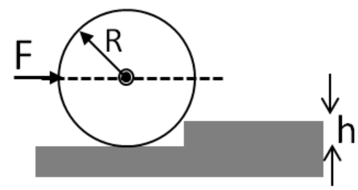

Figure 5.23: Problem 5.6.7.

Problem 5.6.8. A rectangular parallelepiped shaped wooden block of height b and square base of side a is placed on smooth plane. There is a static friction between the block and the plane. As the angle of the plane is varied, the block may either tip over first or slide first depending upon the values of a, b and θ. Find the condition when the block tips first.

Ans: Slide before tip over if $\mu_s < \frac{a}{b}$.

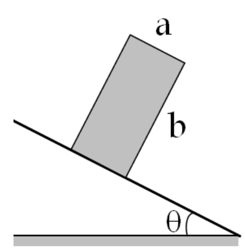

Figure 5.24: Problem 5.6.8.