ME-101 Engineering Mechanics
Tutorial 4 – Friction (14-02-2020)

1. A pulley having a diameter of 80 mm and mass of 125 kg is supported loosely on a shaft having a diameter of 20 mm. Determine the torque ***M*** that must be applied to the pulley to cause it to rotate with constant motion. The coefficient of kinetic friction between the shaft and pulley is μ_k=0.4. Also, calculate the angle θ which the normal force at the point of contact makes with the horizontal. The shaft itself cannot rotate (Fig. 1).

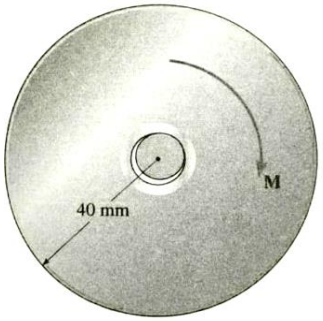

Fig. 1

2. During a particular rescue mission, a rescue worker weighing W = 80kg is to be raised and lowered over the edge of a cliff. The rope attached to the worker is wrapped over 90◦ of the cliff's edge and a one full wrap around a vertical post at the top of the cliff.
   a. Determine the minimum force P required to hold the rescue worker in equilibrium.
   b. Determine the minimum force P required to initiate upward motion of the rescue worker.

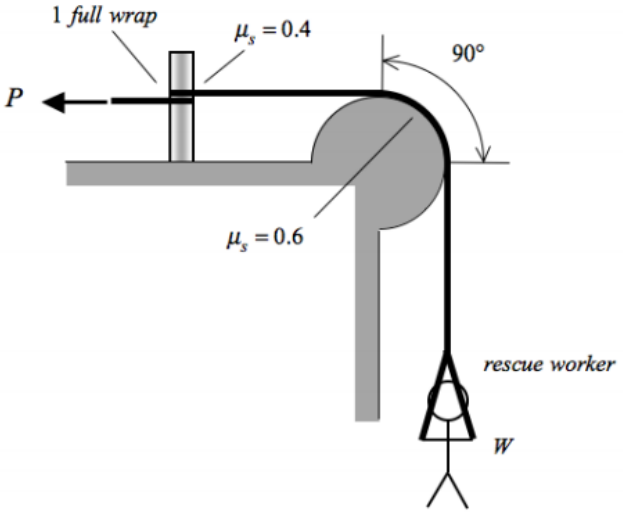

Fig. 2

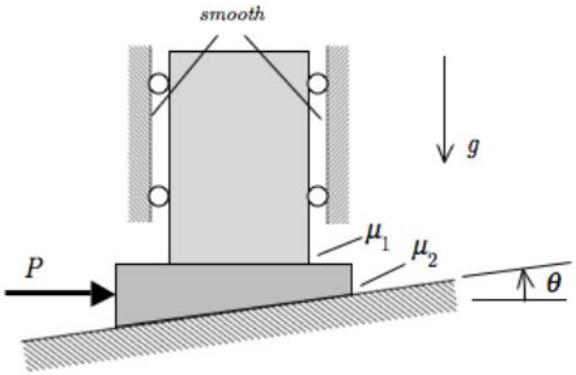

Fig. 3

3. Determine the range of force values P that is required to hold the wedge (negligible mass) and block of weight W in equilibrium (**Fig. 3**). Comment on the wedge if $\mu_1 = \mu_2 = 0.2$ and $\theta = 10^o$.

4. A stack consists of two boxes of same dimensions (**Fig. 4**). Box 1 has a mass of 40 kg box 2 has a mass of 35 kg. The coefficient of friction between the top and bottom boxes is 0.8 and the coefficient of friction between the bottom box and the ground is 0.68. Determine the force at which motion occurs. How do the boxes move? Do they tip or slip? Take H = 1m, h = 0.8m and b = 0.3m.

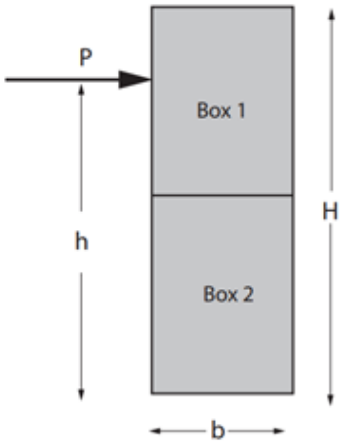

Fig. 4

5. Determine the horizontal force **P** that must be applied perpendicular to the handle of the lever at A in order to develop a compressive force of 12 kN on the material. Each single square threaded screw has a mean diameter of 25 mm and the lead of 7.5 mm. The coefficient of static friction at all contacting surfaces of wedges is μ_s=0.2 and the coefficient of static friction at the screw is μ_s=0.15 (**Fig. 5**).

6. The cylinder is subjected to a load that has a weight ***W*** (**Fig.6**)**.** If the coefficients of rolling resistance for the cylinder's top and bottom surfaces are $\boldsymbol{a_A}$ and $\boldsymbol{a_B}$ respectively. Show that a horizontal force having a magnitude of $\boldsymbol{P \approx [W(a_A + a_B)]/\ 2r}$ is required to move the load and thereby roll the cylinder forward. Neglect the weight of the cylinder. Consider $\boldsymbol{a_A}$ and $\boldsymbol{a_B}$ to be small.

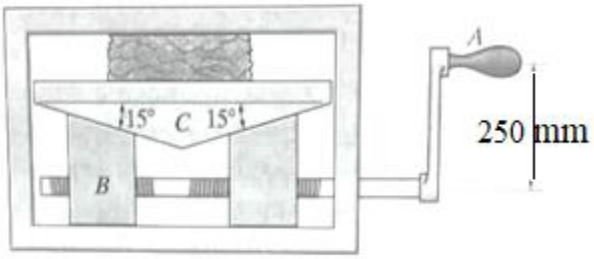

Fig. 5

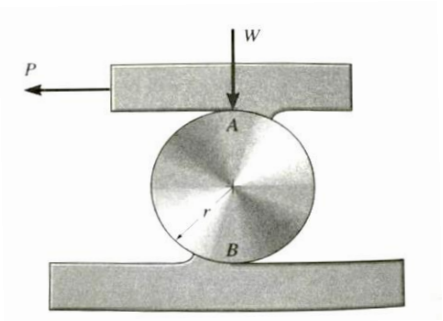

Fig. 6