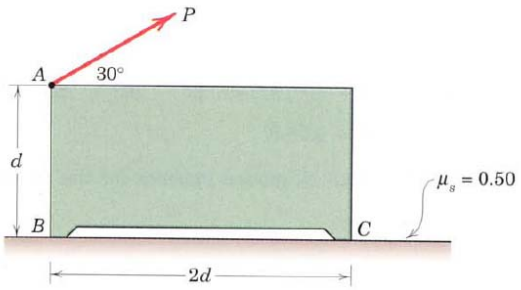
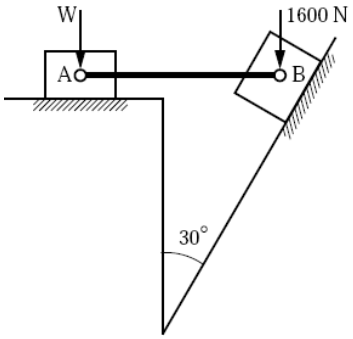
MECHANICS (ME10001)

Tutorial 5: Friction

1. The magnitude of the force P in the direction shown in the figure is slowly increased from zero. Does the homogeneous block of mass m slip or tip first? State the value of P when motion is initiated.

Ans: Slipping occurs first, P=0.448W



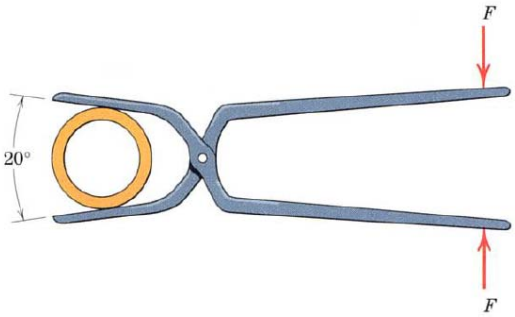


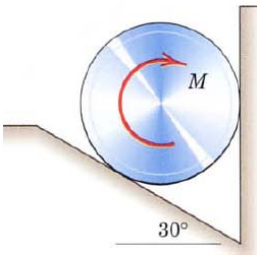
2. Two blocks connected by a horizontal massless link AB are supported on two rough planes as shown. If the coefficient of static friction is μ=0.15, determine the smallest weight W for which the system can be in equilibrium.

Ans: W=13.395 kN

3. For a 20^O jaw opening of the tongs for gripping a tube as shown, determine the minimum required coefficient of static friction at the contacting surfaces for static stability.

Ans. $\mu_{s_{\min}} = 0.176$



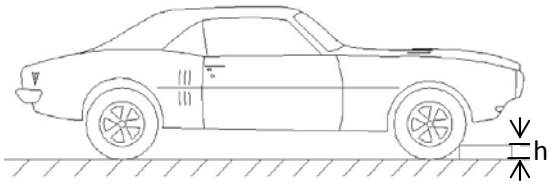


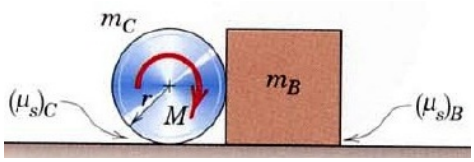
4. The 30 kg homogeneous cylinder of 400 mm diameter rests against the vertical and inclined surfaces as shown. If the coefficients of static and kinetic friction between all contacting surfaces are 0.3 and 0.25, respectively, determine (a) the couple moment M required to initiate rotation, and (b) couple moment M required to rotate the cylinder at a constant speed.

Ans: (a) M=32.92 Nm, (b) M=27.45 kN

5. A car is stopped with its front wheels resting against a curb when its driver starts the engine and tries to drive over the curb. If the radius of the wheels is 280 mm, μ=0.85 between the tyres and the pavement, and 60% of the weight of the car is distributed over its front wheels and 40% over its rear wheels, determine the largest curb height h that the car can negotiate, assuming (a) front-wheel drive, and (b) rear wheel drive.

Ans: (a) h=66.7 mm, (b) h=36.4 mm



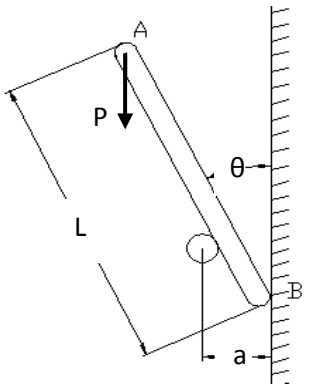


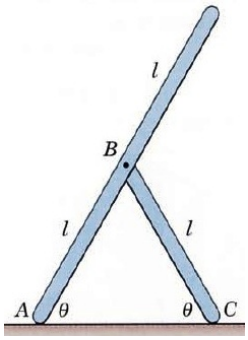
6. A clockwise couple M is applied to the circular cylinder as shown. Determine the value of M required to initiate motion for the conditions m_B =3 kg, m_C=6 kg, $(\mu_S)_B$ =0.5, $(\mu_S)_C$ =0.4, and r=0.2 m. Friction between the cylinder C and block B is negligible.

Ans. $M = 2.94\ \text{N}\cdot\text{m}$

7. A slender rod of length L is lodged between peg C and the vertical wall and supports a load P at the end A. Knowing that Θ=35^{O} and that the coefficient of the static friction is 0.20 at both B and C, find the range of values of the ratio L/a for which equilibrium is maintained .

Ans: 3.46 <= L/a <= 13.63.



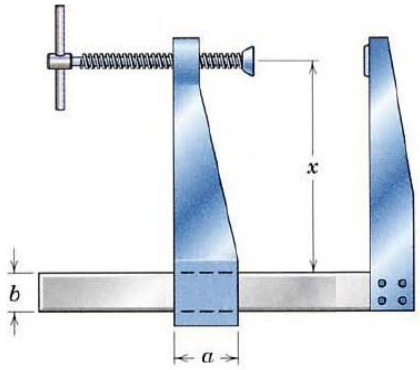


8. The two uniform slender bars are freely pinned together at B. Determine the minimum angle theta at which slipping does not occur at either point A or C. Take μ_S =0.5 at the contacts at A and C, and consider only impending motion in the vertical plane shown.

Ans: θ=63.4^{O} (contact A slips)

9. The movable jaw of the C-clamp can slide along the frame to increase the capacity of the clamp. To prevent slipping of the jaw on the frame when the clamp is under load, the dimension x must exceed a certain minimum value. For given values of a and b and static friction coefficient μ_S, specify this minimum value of x to prevent slippage of the jaw.

$$Ans.\ x = \frac{a - b\mu_s}{2\mu_s}$$

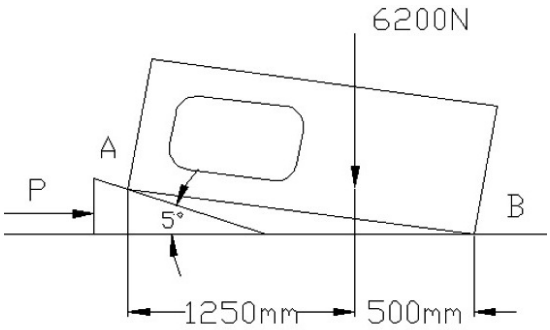


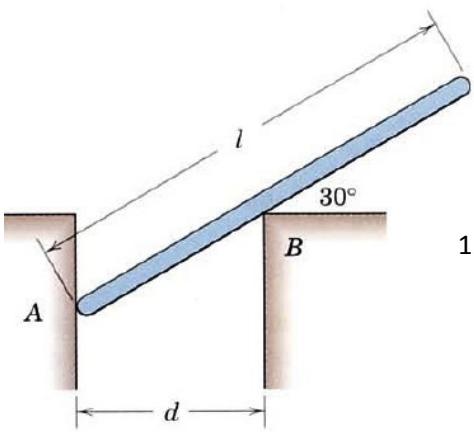
10. The three identical rollers are stacked on a horizontal surface as shown. If the coefficient of static friction μ_S is same for all pairs of contacting surfaces, find the minimum value of μ_S for which the rollers will not slip.

$$Ans.\ \mu_s = 0.268$$

11. A 5 deg massless wedge is to be forced under a 6200N machine base at A. Knowing that μ_S=0.2 at all contacting surfaces, (a) determine the force P required to move the wedge. (b) Check whether the machine will slide at contact B. Neglect the thickness of the wedge.

Ans: P=854.1 N (no slip at contact B)



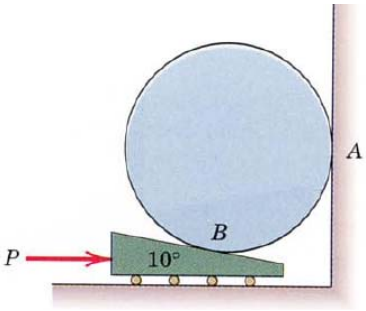


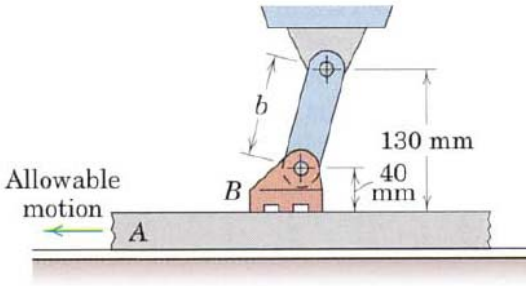
12. The uniform slender bar of length l is placed in the opening of width d at the 30 deg angle shown. For what range of l/d will the bar remain in static equilibrium? The coefficient of static friction at A and B is μ_S =0.4.

Ans: 2.37 <= l/d <= 8.14

13. Calculate the horizontal force P on the light 10 deg wedge necessary to initiate movement of the 40 kg cylinder. The coefficient of static friction μ_S=0.25 for both pairs of contacting surfaces. Also determine the friction force F_B at point B.

Ans. $P = 98.6$ N, $F_B = 24.6$ N



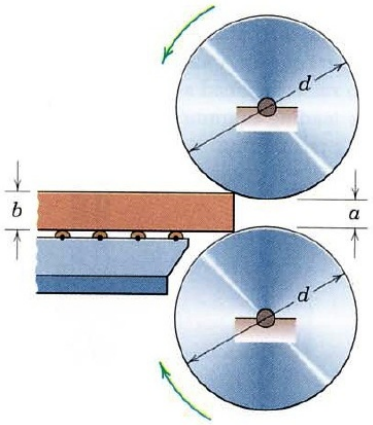


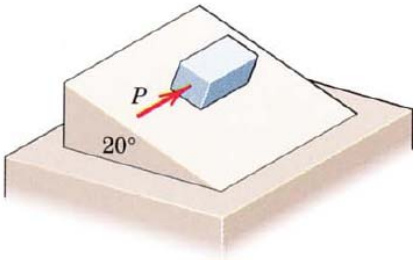
14. A frictional locking device allows bar A to move to the left but prevents movement to the right. If the coefficient of friction between the shoe B and the bar A is 0.40, specify the maximum length b of the link which will permit the device to work as described.

Ans. $b = 96.9$ mm

15. The elements of a rolling mill are shown here. In the design of the roller spacing, determine the maximum slab thickness b so that the slab will enter the rollers by means of friction alone if the coefficient of kinetic friction is μ_K. Assume that (b-a) is small compared to d.

Ans: $b=a+0.5d\,(\mu_K)^2$



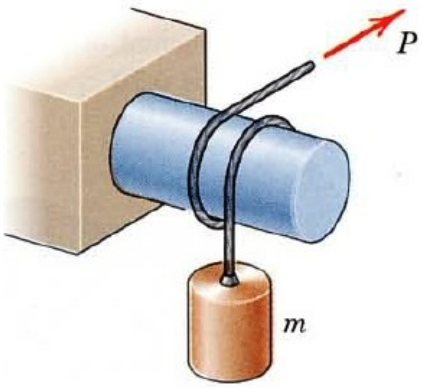


16. The 8 kg block is resting on the 20^O inclined plane with a coefficient of static friction 0.50. Determine the minimum horizontal force P which will cause the block to slip.

Ans. $P = 25.3$ N

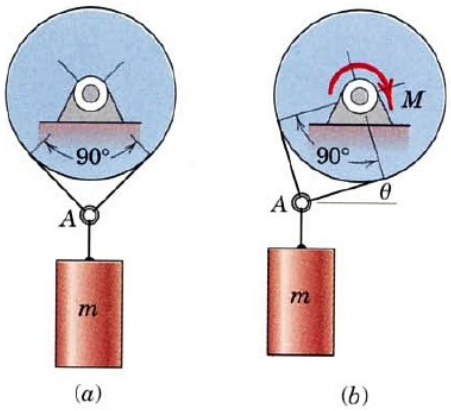
17. A force P=mg/6 is required to lower the cylinder at a constant slow speed with the cord making 1 and ¼ turns around the fixed shaft. Calculate the force P that will be required to raise the cylinder at a constant slow speed.

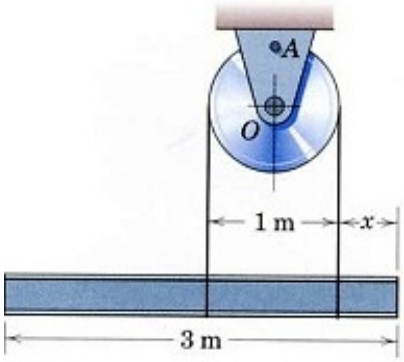
Ans: μ=0.228



18. The cylinder of mass m is attached to the ring A, which is suspended by the cable that passes over the pulley as shown in (a). A couple M applied to the pulley turns it until slipping of the cable over the pulley occurs at the position $\theta=20^{O}$, as shown in (b). Calculate the coefficient of friction μ between the cable and the pulley.

Ans: μ=0.215



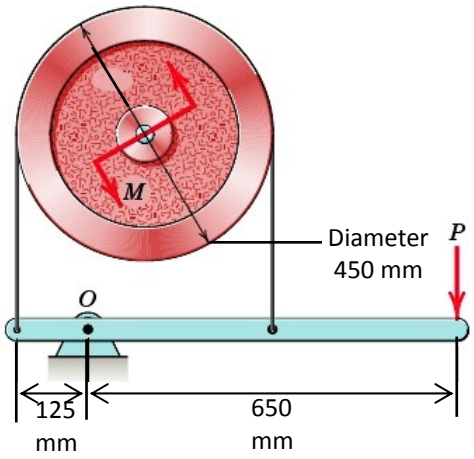


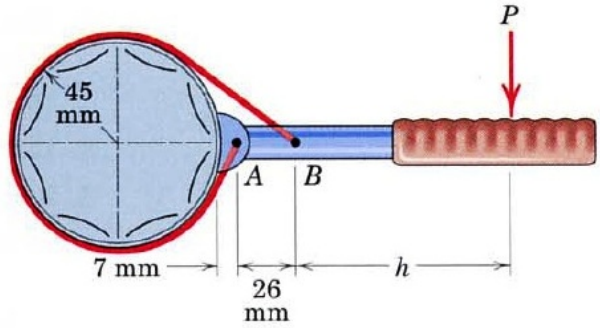
19. The uniform 3 m beam is suspended asymmetrically by the cable which passes over the large pulley which is locked by a locking pin at A. If the coefficient of friction between the cable and the pulley is 0.25, determine the minimum value of x for which the cable will not slip on the pulley.

Ans: x=0.813 m

20. A moment M=150 Nm is applied to the flywheel. If the coefficient of friction between the band and the wheel is 0.20, determine the minimum force P required to prevent the wheel from rotating.

Ans: P=567.93 N





21. The coefficient of friction between the flexible band of a band-type wrench and the fixed cylinder is 0.25. Determine the minimum value of h which ensures that the wrench will not slip on the cylinder regardless of the magnitude of P. Assume that the band at A starts tangentially to the cylinder from θ=0 and runs clockwise as shown.

Ans. $h = 27.8$ mm

22. A rope passes over a fixed surface at A, an idler (frictionless) pulley B of radius 100mm and another fixed pulley C of radius 200mm, as shown in the Fig.6. A force F is applied at one end of the rope to prevent falling of the weight of 1000N at the other end. If the co-efficient of friction between the rope and the surfaces at A and C is 0.3, determine the value of F.

Ans: F=243 N