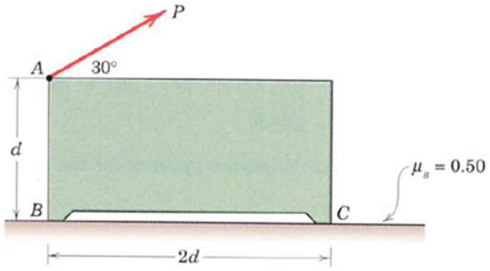
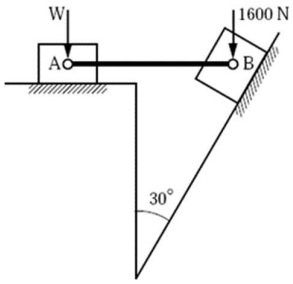
BASIC ENGINEERING MECHANICS (ME11003)

Tutorial 3: 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.

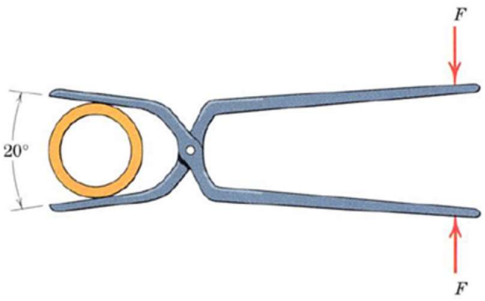


Ans: *Slipping occurs first, P=0.448W*



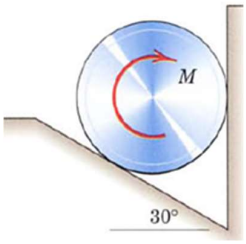
2. Two blocks connected by a horizontal massless link AB are supported on two rough planes as shown. If the coefficient of static friction is μ=0.15, determine the smallest weight W for which the system can be in equilibrium.

Ans: *W=13.395 kN*



3. For a 20° 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.

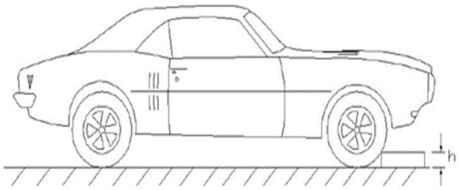
Ans: $\mu_{s\_min} = 0.176$



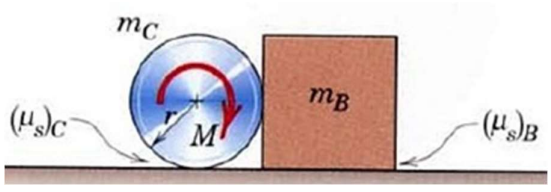
4. The 30 kg homogeneous cylinder of 400 mm diameter rests against the vertical and inclined surfaces as shown. If the coefficients of static and kinetic friction between all contacting surfaces are 0.3 and 0.25, respectively, determine (a) the couple moment M required to initiate rotation, and (b) couple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

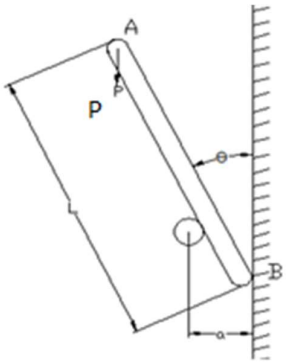


6. A clockwise couple M is applied to the circular cylinder as shown. Determine the value of M required to initiate motion for the conditions m_B =3 kg, m_C=6 kg, $(\mu_S)_B$ =0.5, $(\mu_S)_C$ =0.4, and r=0.2 m. Friction between the cylinder C and block B is negligible.

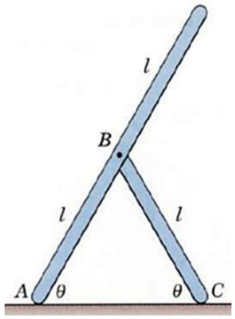
Ans: *M=2.94 N.m*

Problems taken from various sources. Figures not own.

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° 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.



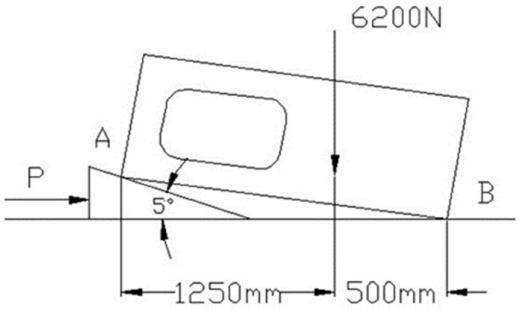
Ans: *3.46 <= L/a <= 13.63*



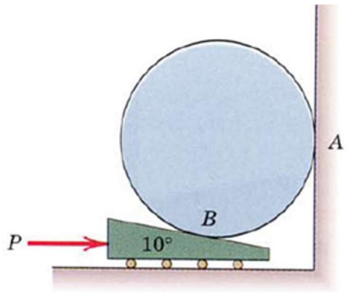
8. The two uniform slender bars are freely pinned together at B. Determine the minimum angle theta at which slipping does not occur at either point A or C. Take μ_S =0.5 at the contacts at A and C, and consider only impending motion in the vertical plane shown.

Ans: *θ=63.4⁰ (contact A slips)*

9. A 5° 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.



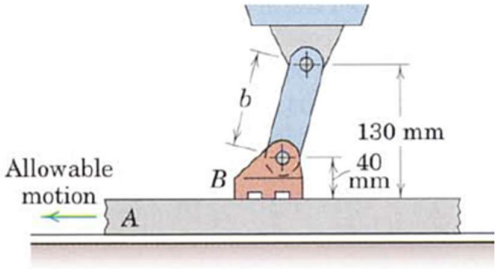
Ans: *P=854.1 N (no slip at contact B)*



10. 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 = 24.6N*

11. 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.

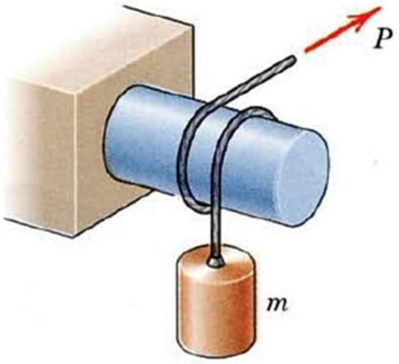


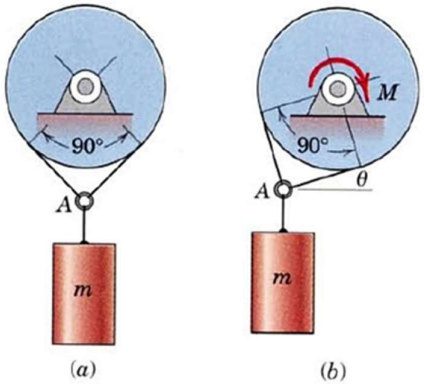
Ans: *b=96.9 mm*

Problems taken from various sources. Figures not own.

12. 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*

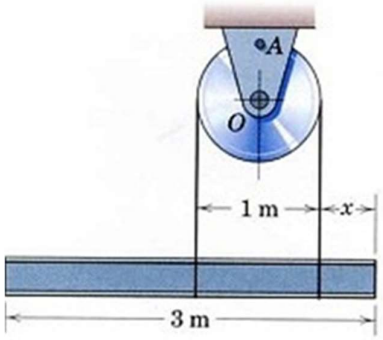




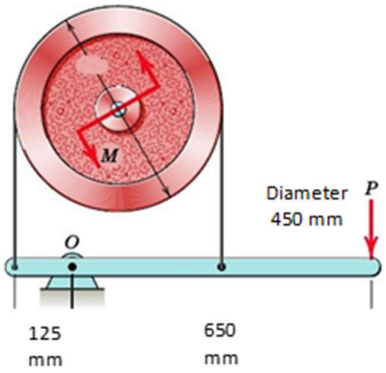
13. The cylinder of mass m is attached to the ring A, which is suspended by the cable that passes over the pulley as shown in (a). A couple M applied to the pulley turns it until slipping of the cable over the pulley occurs at the position $\theta=20^{O}$, as shown in (b). Calculate the coefficient of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

Ans: *μ=0.215*

14. 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*

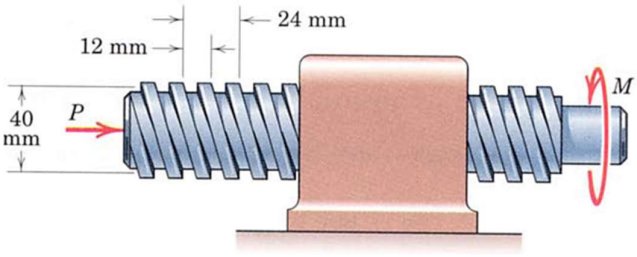


15. A moment M=150 Nm is applied to the flywheel. If the coefficient of friction between the band and the wheel is 0.20, determine the minimum force P required to prevent the wheel from rotating.

Ans: *P=567.93 N*

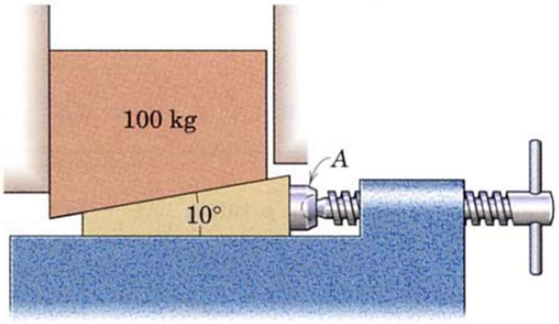
16. A 40 mm diameter screw has a double square thread with pitch of 12 mm and lead of 24 mm. The screw and its mating threads in the fixed block are lubricated to have a friction coefficient of 0.15. If a torque M=60 Nm is applied to the right-hand portion of the shaft, determine (a) the force P required to advance the shaft to the right, and (b) the force P which would allow the shaft to move to the left at a constant speed.

Ans: *(a) P=75.3 kN, (b) P=8.55 kN*

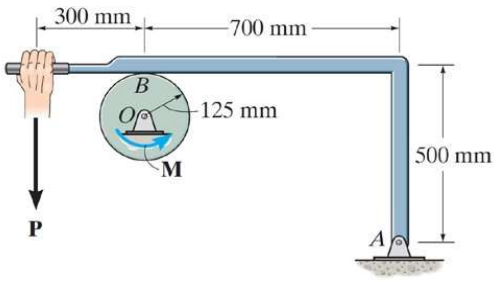


Problems taken from various sources. Figures not own.

17. The vertical position of the 100 kg block is adjusted by the screw activated wedge. Calculate the moment M which must be applied to the handle of the screw to raise the block. The single square threaded screw has a mean diameter of 30 mm and advances 10 mm for each complete turn. The coefficient of friction for the screw threads is 0.25, and that for all mating surfaces of the block and wedge is 0.4. Neglect friction at the ball joint A.



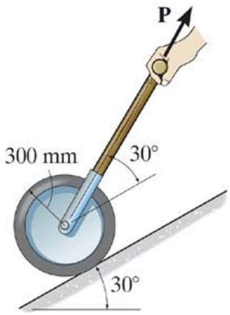
Ans: *M=7.30 Nm*



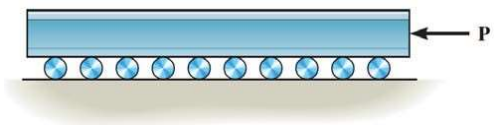
18. The coefficient of static and kinetic friction between the drum and the brake bar are 0.4 and 0.3, respectively.
a.) If $\mathbf{M} = 50$ Nm and $\mathbf{P} = 85$ N determine the magnitude of the reaction at pin O. The drum has mass of 25 kg and the weight of the brake lever is negligible.
b.) If $\mathbf{M} = 35$ N determine the smallest force **P** applied to the brake bar in order to stop the drum from rotating

Ans: *(a) 402.68 N, (b) 350 N*

19. The roller has 50 kg mass and the coefficient of rolling resistance aa = 15 mm.
a) Determine the force P required to pull the roller up the inclined plane at a constant velocity.
b) Determine the force P required to support the roller when it rolls down the inclined plane at a constant velocity.



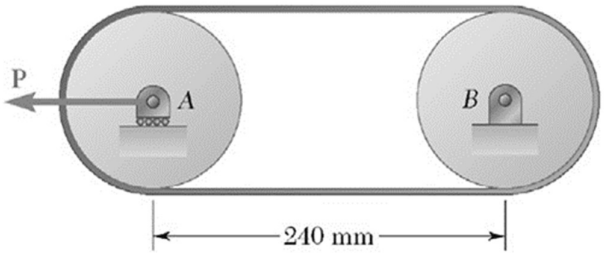
Ans: *(a) 299 N, (b) 266 N*



20. The 1.2 Mg steel beam is moved over a level surface by using a series of 30 mm rollers for which the coefficient of rolling resistance is 0.4 mm at the softer ground and 0.2 mm at the harder bottom surface of the beam. Determine the horizontal force P needed to push the beam forward at a constant speed.

Ans: *P=235 N*

21. A flat belt is used to transmit power from pulley A to pulley B at a constant speed of 600 RPM. The radius of each pulley is 60 mm, and a tightening force $\mathbf{PP} = 900$ N is applied to the axle of pulley A. Knowing that the coefficient of static friction between the belt and the pulley is 0.35 and the maximum allowable tension in the belt is 1 kN, determine the largest power that can be transmitted by (a) the system as shown and (b) the system when the belt is looped around the pulleys in a figure of 8 (eight rotated by 90° angle).



Ans: *1.7 kW and 2.45 kW*

Problems taken from various sources. Figures not own.