Lec24

Monday, November 16, 2020 8:01 AM

Lecture Objectives

Friction

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Friction

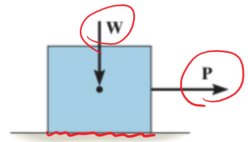
Friction is a force that resists the movement of two contacting surfaces that slide relative to one another. This force acts tangent to the surface at the points of contact and is directed so as to oppose the possible or existing motion between the surfaces.

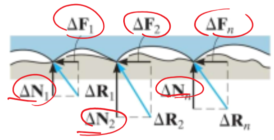
Dry Friction (or Coulomb friction) occurs between the contacting surfaces of bodies when there is no lubricating fluid.

Figure: 08_COC

The effective design of each brake on this railroad wheel requires that it resist the frictional forces developed between it and the wheel. In this chapter we will study dry friction, and show how to analyze friction forces for various engineering applications.

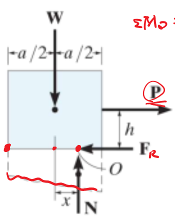
Dry friction





- Consider the effects of pulling horizontally (force **P**) a block of weight **W** which is resting on a **rough** surface.
- The floor exerts an uneven distribution of normal forces $\Delta \boldsymbol{N}_n$ and frictional forces $\Delta \boldsymbol{F}_n$ along the contacting surface.
- These distributed loads can be represented by their equivalent resultant normal forces ***N*** and frictional forces ***F***

Dry friction



$\Sigma M_O = W \cdot x - P \cdot h = 0$

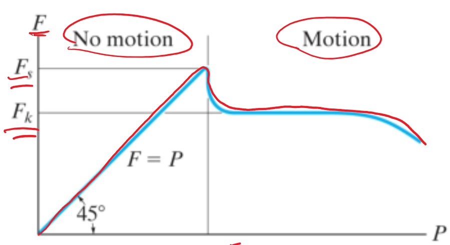
$x = \dfrac{P h}{W}$

$Max(x) = \dfrac{a}{2}$

$F < F_s$: No motion

$F = F_s$: Pending

$F > F_s$: In motion



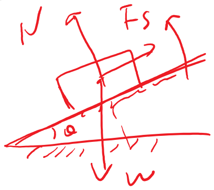
$F_K < F_s$ $\qquad$ $F_k = \mu_k \cdot N$

Table 8–1 Typical Values for μ_s

Contact Materials	Coefficient of Static Friction (μ_s)
Metal on ice	0.03–0.05
Wood on wood	0.30–0.70
Leather on wood	0.20–0.50
Leather on metal	0.30–0.60
Aluminum on aluminum	1.10–1.70

Determine μ_s Experimentally

A block with weight W is placed on an ~~inclined plane~~. What will happen to the block when the plane is slowly tilted?



$\theta \uparrow$

$N = W \cdot \cos\theta$ ①

$F_s = W \cdot \sin\theta$ ②

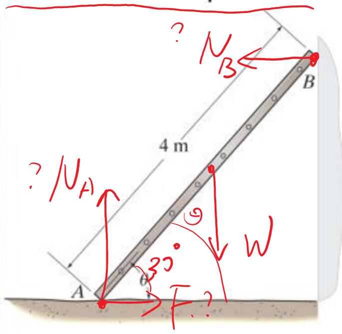
$F_s = \mu_s N$

$$\frac{N}{\mu_s N} = \frac{1}{\tan\theta}$$

$$\mu_s = \tan\theta$$

Example

A metal ladder with a mass of 10 kg is leaning against a smooth wall on an icy ground. Can it maintain equilibrium if ϑ =30°?



$\Sigma F_x = F - N_B = 0$

$\Sigma F_y = N_A - W = 0$

$\Sigma M_A = N_B \, 4 \cdot \sin 30° - W \cdot \frac{1}{2} 4 \cdot \cos 30° = 0$

$N_A = 98N$. $N_B = 49\sqrt{3}\ N$, $F = N_B = 49\sqrt{3}\ N$

0.03 – 0.05

$F_s = \mu_s \cdot N = (2.94N,\ 4.9N)$

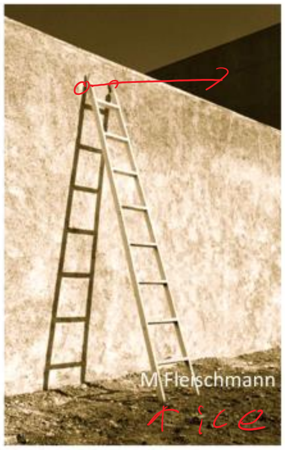
98N

$F > F_s$

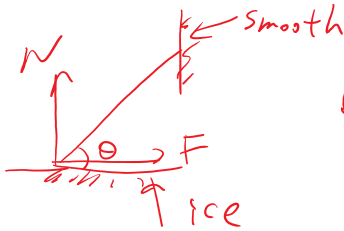
Can't maintain equilibrium

i-Clicker

For the same ladder leaning against a smooth wall on an icy ground, will the ladder be more or less likely to maintain equilibrium if ϑ decreases?



A) More likely to maintain equilibrium
B) Less likely to maintain equilibrium
C) More information is needed
D) Does not make any difference



$N = W$

$\theta \downarrow$, $N \leftarrow$

$F \uparrow$

F_s —

i-Clicker Time

A 10 lb block is in equilibrium. What is the magnitude of the friction force between this block and the surface?

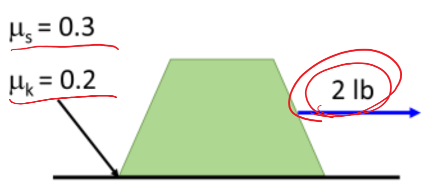
A) 0 lb

B) 1 lb

C) 2 lb

D) 3 lb

E) None of the above



$P < F_s = 3\text{ lb}$

$F = P$

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i-Clicker Time

A 10 lb block is sliding. What is the magnitude of the friction force between this block and the surface?

A) 1 lb

✓B) 2 lb

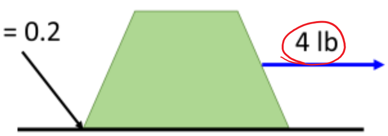
B) 3 lb

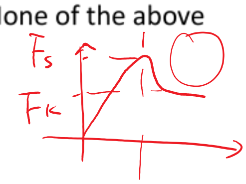
C) 4 lb

D) None of the above

$\mu_s = 0.3$

$\mu_k = 0.2$





$P > \mu_s \cdot N = 3\ lb$

$F_f = F_k = \mu_k \cdot N = 2\ lb$

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i-Clicker Time

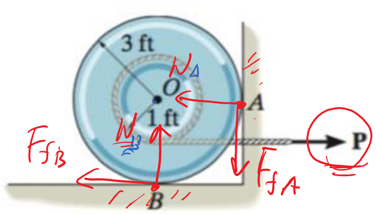
What are the directions of friction forces at *A* and *B*?

A) A ↓ B ⟶

B) A ↓ B ⟵

C) A ↑ B ⟶

D) A ↑ B ⟵



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