Lesson 2.2 – Static & Kinetic Friction

Unit 2: Dynamics and Equilibrium

Static Friction:

Recall F_N (the normal force): *the component force perpendicular to the surface*

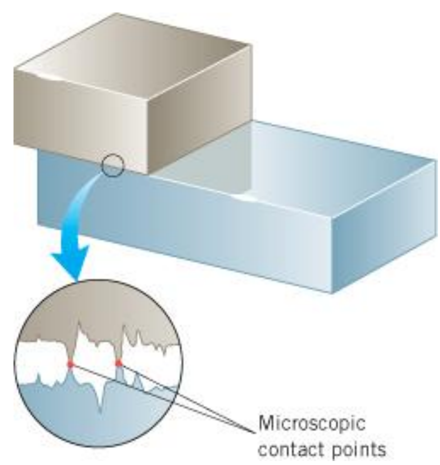
Frictional Force: A force parallel to a surface that prevents motion when an object is at rest.

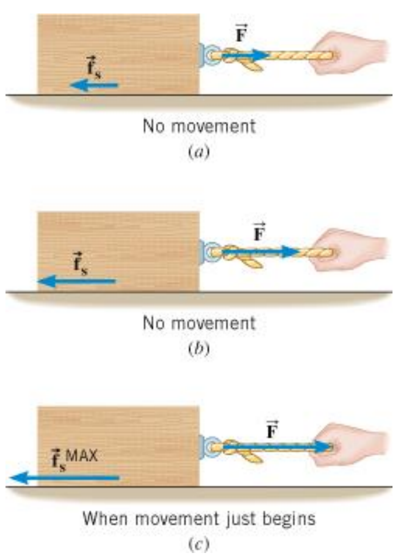
List some situations you can think of where engineering efforts attempt to:

Reduce Friction	Increase Friction

What causes friction? (simulation) *try this after talking about surfaces*

Surfaces touch only at tiny microscopic points → intermolecular attraction forms tiny "cold welds."



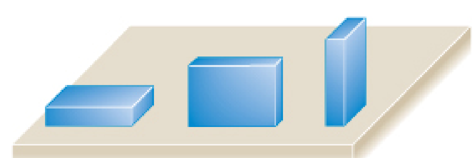


Friction is self-adjusting:

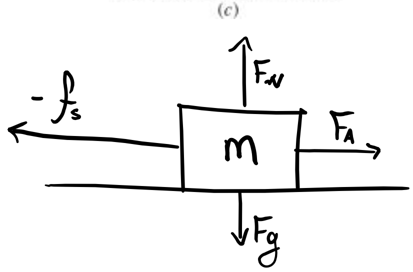
Static friction matches the applied force up to a maximum value (before moving).

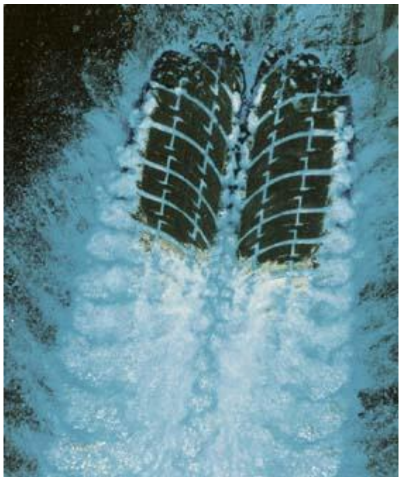
Maximum static friction:

$$f_s^{max} = \mu_s F_N$$



- Depends on the normal force.
- Coefficient is unitless (ratio of f_s:F_N)
- Independent of surface area
- If f_s^{max} is exceeded, motion begins
- $f_s \leq f_s^{max}$ *(more normal force = more friction)*





This photo, shot from underneath a transparent surface, shows a tire rolling under wet conditions.

Why do you think tire engineers put these channels (tread) in the rubber?

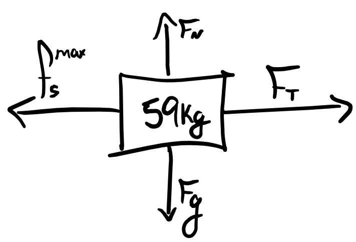
A: to collect and divert water away from the regions of contact to increase traction.

What are F1 drivers doing when the [swerve back and forth]() and [spin their wheels]() before a race?

A: heating them up increases f_s^{max}.

Example 1: A 59-kg skier stands at rest on level snow about to get on the tow rope. If $\mu_s = 0.14$, what is the maximum horizontal force a tow rope can apply without moving her?

$m = 59\text{kg}$
$\mu_s = 0.14$
$g = 9.8 \text{m/s}^2$



$f_s^{max} = \mu_s F_N$

$f_s^{max} = \mu_s mg$

$= 0.14(59\text{kg})(9.8\text{m/s}^2)$

$\boxed{= 81N}$

$\vec{F}_{net_y} = m\vec{a}$

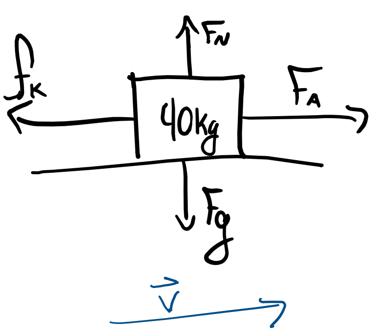
$F_N - F_g = 0$

$\boxed{F_N = F_g = mg}$

Kinetic Friction:

- Acts when surfaces are sliding (in motion)
- Opposes the direction of motion
- Less than f_s^{max}
- Independent of contact area
- Independent of speed (at low speeds)
- Proportional to the normal force

Example 2: A 40. Kg box is pushed with constant velocity over a surface with $\mu_k = 0.15$. What force is being applied?



$F_{net_y} = m\vec{a} = 0$

$\therefore F_N = F_g = mg$

$F_{net\,x} = m\underbrace{\vec{a}}_{=0}$

$F_A - f_K = m(0) = 0$

$F_A = \mu_K F_N = \mu_K mg$

$F_A = 0.15(40)(9.8)$

$= 58.8N$ or $\boxed{59N}$

Assignment: WS 2.2 – Static and Kinetic Friction