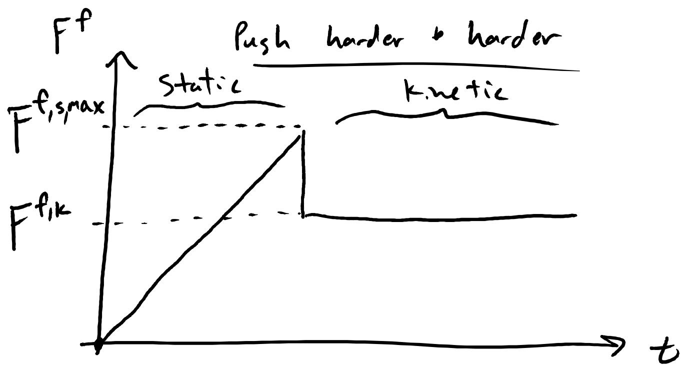
Friction

* Hard to break free ....easier to keep moving once free



* Friction is ∥ surface
* associated w/ a normal Force
* Friction opposes the direction of relative motion
  * ask which way move if frictionless

Model

Static

$$|\vec{F}^{f,s,max}| = \mu_s |\vec{F}^N|$$

↑ coefficent of static friction

Kinetic

$$|\vec{F}^{f,k}| = \mu_k |\vec{F}^N| = \text{const.}$$

↑ coefficent of kinetic friction

$\mu_s \geq \mu_k$ ⟶ Both properties of both surfaces

Example: A 80 kg man, wearing skis on snow, is pulled via a rope from a truck on level ground. The magnitude of the force from the truck 800 N and is directed at an angle of 30° above the horizontal.

For part (c) and (d) consider friction present with $\mu_s = 1/3$ and $\mu_k = 1/4$ and let $g = 10$ m/s^2.

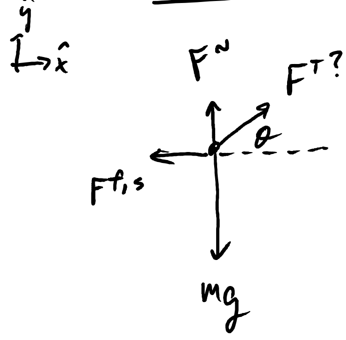
(c) How much tension is required to get the skier to slip? (261 N)

(d) If the minimum slip tension is doubled, what will the acceleration be? (4.08 m/s^2)

c.) F_{min} to slip — FBD (Man)

$|F^{f,s,max}| = \mu_s |F^N|$

Solve w/ static @ max friction



$$\Sigma F_y \Rightarrow F^N + F^T \sin\theta + (-mg) = m a_y^{\nearrow 0} \Rightarrow F^N = mg - F^T \sin\theta$$

$$\Sigma F_x \Rightarrow \underbrace{F^T \cos\theta - \mu_s \underbrace{(mg - F^T \sin\theta)}_{F^N}}_{F^{f,s,max}} = m a_x^{\nearrow 0}$$

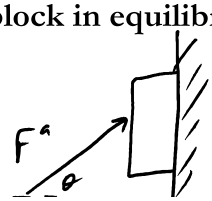
$$F^T_{min} > \frac{\mu_s mg}{\cos\theta + \mu_s \sin\theta} > 261\ N$$

d.) $F^T_{min} \to 2F^T_{min}$, $F^{f,s,max} \to F^{f,k}$

$$\Sigma F_x \Rightarrow F^T(\cos\theta - \mu_k \sin\theta) - \mu_k mg = m a_x , \quad \boxed{a_x = 4.08\ m/s^2}$$

$$\Sigma F_y \Rightarrow F^T_y < mg \text{ so, } \boxed{a_y = 0}$$

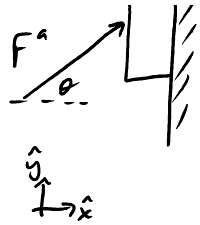
Example: A force is applied to a 1-kg-block that is pressed against a vertical wall. The force is at an angle of 40° upward from the horizontal. If the coefficient of static friction between the block and the wall is 0.3, what range of forces will keep the block in equilibrium? (Answer = 11.2 – 23.7 N)

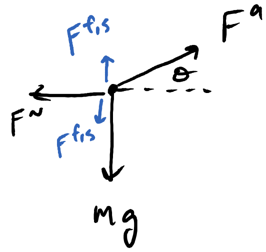


FBD (Block)

$\boxed{x}$ $\Sigma F_x \Rightarrow F^a \cos\theta - F^N = m a_x^{\nearrow 0}$

$F^N = F^a \cos\theta$





$F^N = F^a \cos\theta$

[y] $F^{f,s,max}$ upward (min F^a)

$$+\underbrace{\mu_s F^N}_{F^{f,s,max}} + F^a_{min}\sin\theta - mg = m\cancel{a_y}^{\,0}$$

Solve for $\boxed{F^a_{min} = 11.2\,N}$

For F^a_{max} .... switch direction of friction

.... same steps

$\boxed{F^a_{max} = 23.7\,N}$