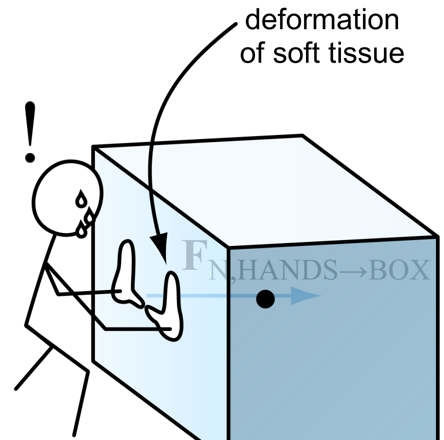
Forces

Forces occur through interactions between pairs of objects

A **force** is a directed push or a directed pull exerted on an object by *another* object.

The preceding statement merely associates one term, force, that is yet to be defined with alternative terms, “push” and “pull,” that are likewise not defined. **Force is a postulated** (vector) **quantity**.



$[F] = \mathrm{N}$

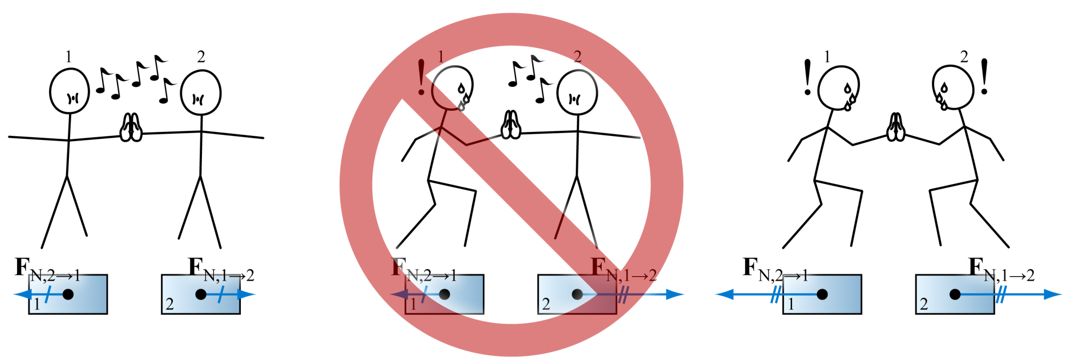
Newton III

There exists $\vec{\mathbf{F}}_{\_\_,2\to1}$

$\Rightarrow$

there also exists

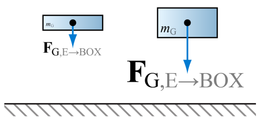
$$\vec{\mathbf{F}}_{\_\_,1\to2} = -\vec{\mathbf{F}}_{\_\_,2\to1}$$



Forces

Examples of common forces

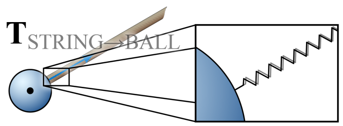
Weight ((nearly) on Earth)
toward Earth



$$F_G = m_G g$$

$[m_G] = \text{kg}$ $g = 9.8\ \frac{\text{m}}{\text{s}^2}$

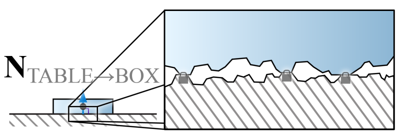
Tension
back into string

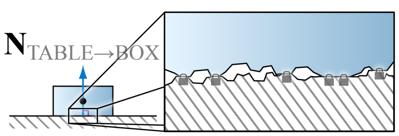


$$T$$

No memorized formula

Normal
⊥ push

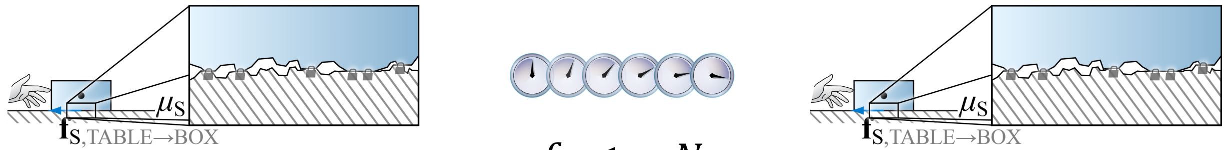




$$N$$

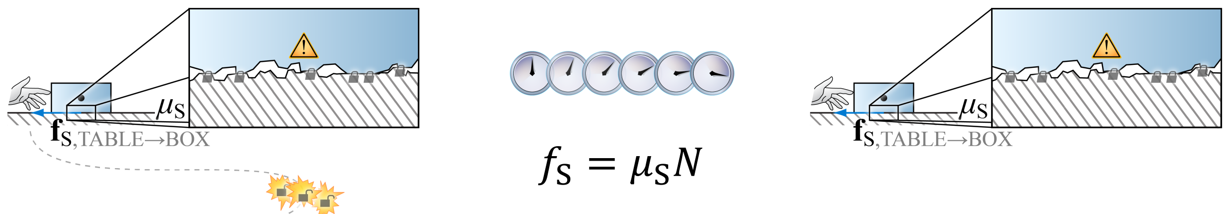
No memorized formula

Static friction
∥ to interface, opposes interfacial slippage
Case I. Less than maximum that can be sustained for a given normal force



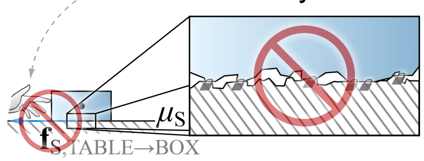
$$f_S < \mu_S N$$

Case II. Maximum that can be sustained for a given normal force



$$f_S = \mu_S N$$

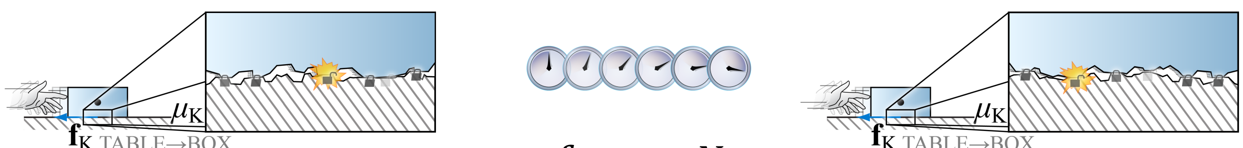
Case III. Beyond maximum that can be sustained for a given normal force



"According to $f_S \leq \mu_S N$, f_S _cannot_ exceed $\mu_S N$. If … _were_ stuck, … f_S _would_ need to equal …, exceeding $\mu_S N$. So, instead of being stuck, … must have slipped."

$$f_S > \mu_S N$$

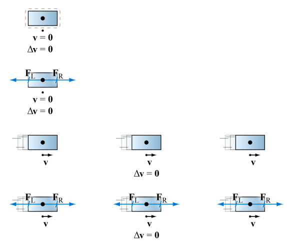
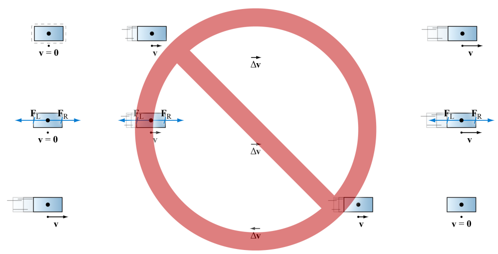
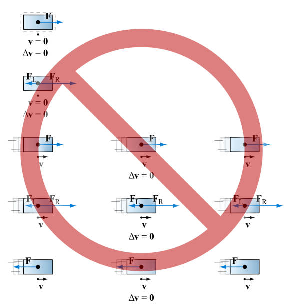
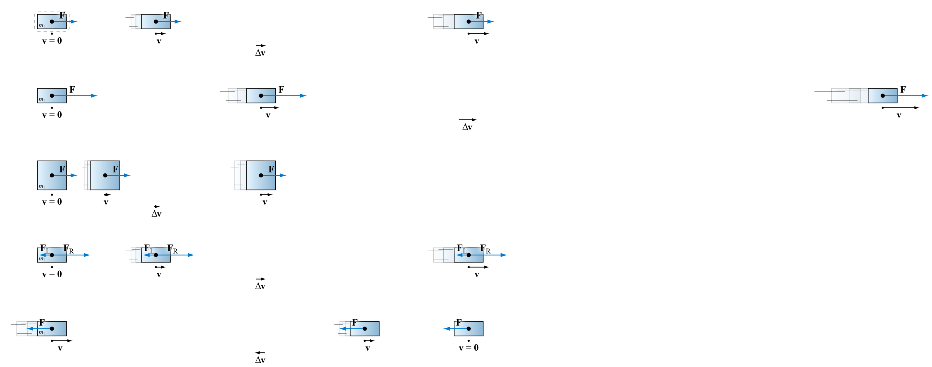
Kinetic friction
∥ to interface, opposes interfacial slippage



$$f_K = \mu_K N$$

Forces

How are force and acceleration related for material objects**?**

	$\vec{\mathbf{a}} = \vec{\mathbf{0}}$ constant $\vec{\mathbf{v}}$	$\vec{\mathbf{a}} \neq \vec{\mathbf{0}}$ changing $\vec{\mathbf{v}}$
$\sum \vec{\mathbf{F}} = \vec{\mathbf{0}}$		
$\sum \vec{\mathbf{F}} \neq \vec{\mathbf{0}}$		

Newton I for material objects

$$\sum \vec{\mathbf{F}} = \vec{\mathbf{0}} \Leftrightarrow \begin{cases} \vec{\mathbf{a}} = \vec{\mathbf{0}} \\ \text{constant } \vec{\mathbf{v}} \end{cases}$$

inertial frame – frame of reference in which Newton's first law holds

Newton II for material objects

$$\vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m_{\mathrm{I}}}$$

An object's inertial mass is the amount of that object's tendency to not accelerate.

$$[m_{\mathrm{I}}] = \mathrm{kg}$$

An inertial mass of $1\ \mathrm{kg}$ requires precisely $1\ \mathrm{N}$ of net force in order to have an acceleration of $1\,\frac{\mathrm{m}}{\mathrm{s}^2}$.