

Friction

Engineering Mechanics: Dynamics

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Friction

- ▶ models the interaction between objects in contact
- ▶ opposes the relative motion between objects

Experimental observations (Leonardo da Vinci, 1452–1519; Guillaume Amontons, 1663–1705; Charles-Augustin de Coulomb, 1736–1806)

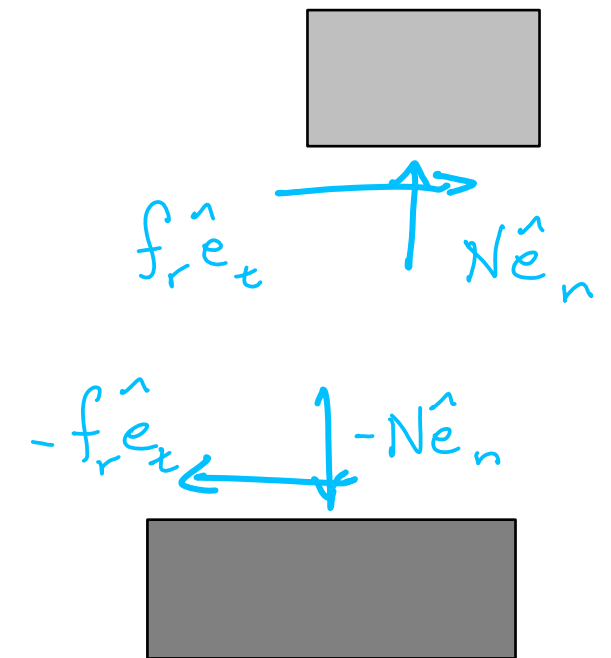
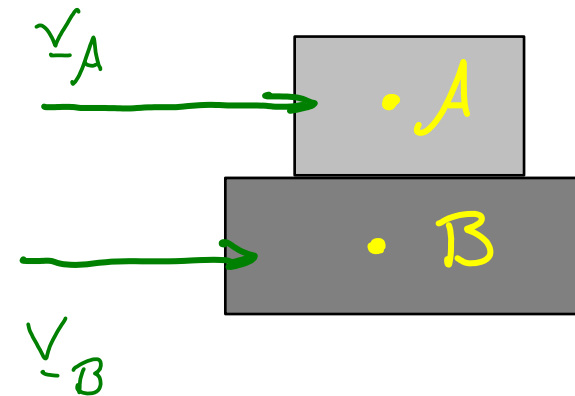
- INDEPENDENT OF CONTACT AREA
- RELATIVE MOTION
 - INDEPENDENT OF SLIDING VELOCITY
 - PROPORTIONAL TO NORMAL FORCE



$$\underline{v}_{\text{SLIP}} = \underline{v}_A - \underline{v}_B = v_{\text{SLIP}} \hat{e}_t$$

$$\underline{N} = N \hat{e}_n : \text{NORMAL}$$

$$\underline{f}_r = f_r \hat{e}_t : \text{FRICTION}$$



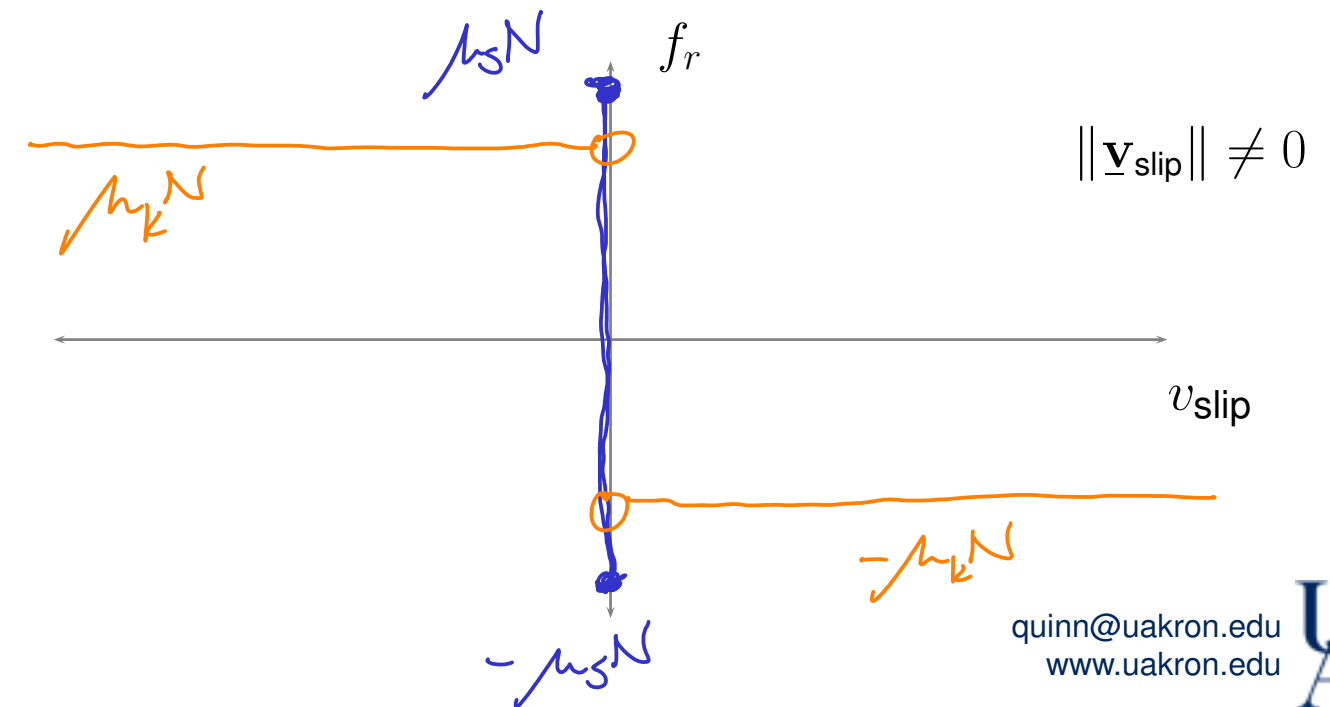
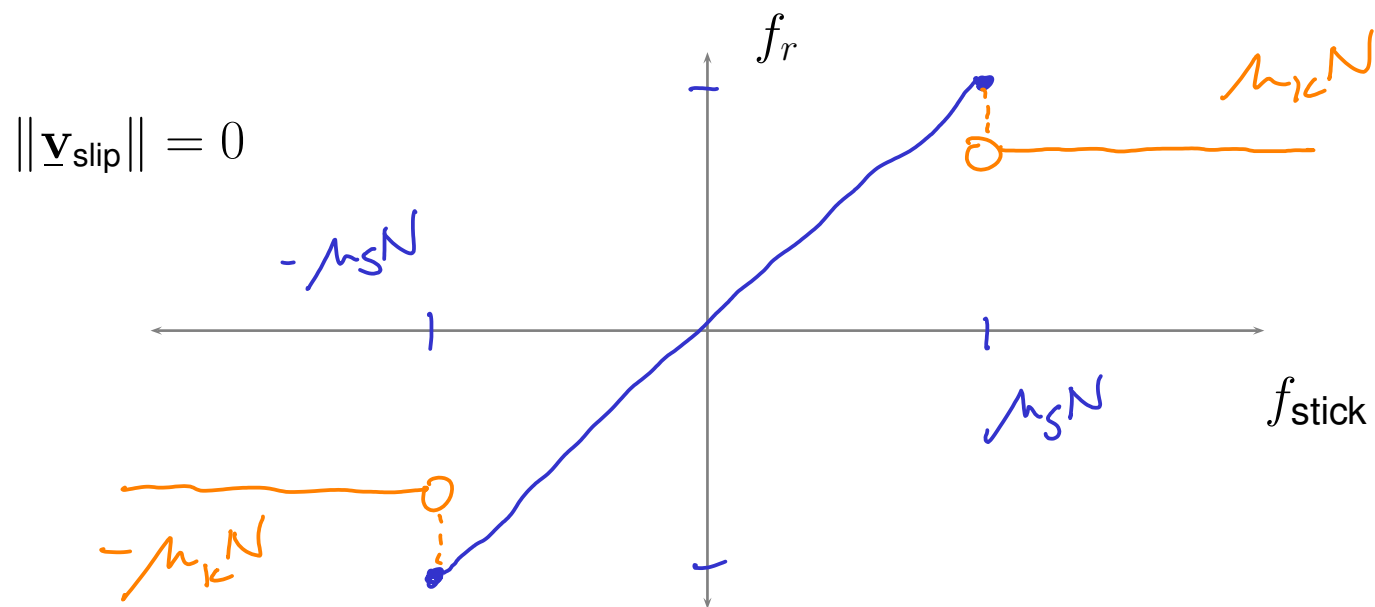
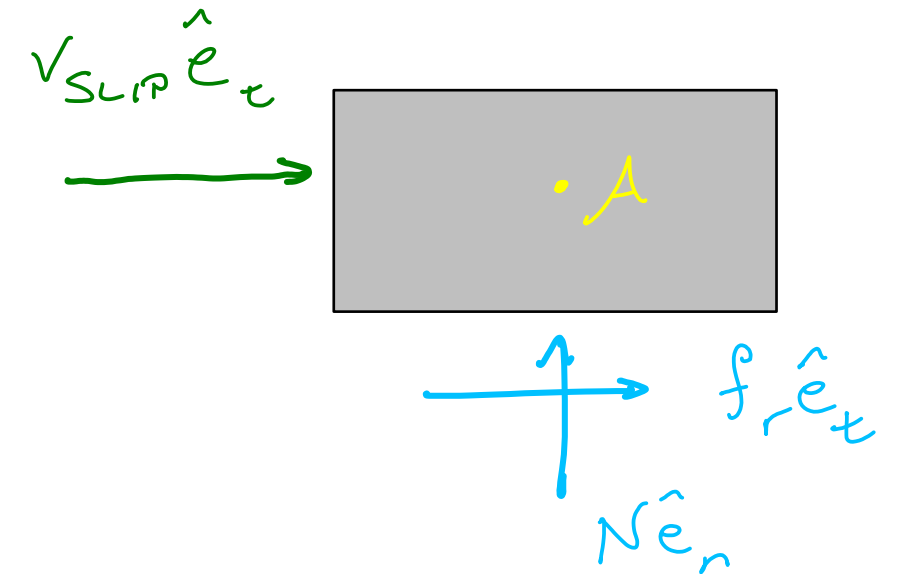
Coulomb friction (most common model for friction)

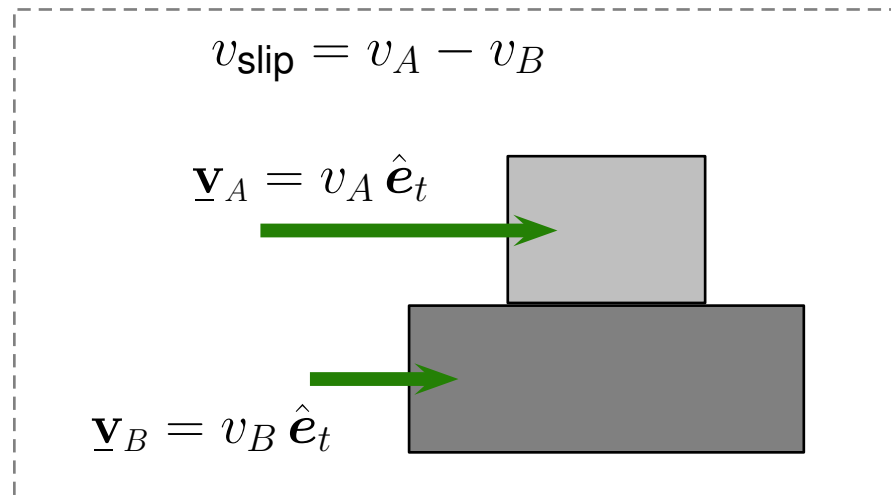
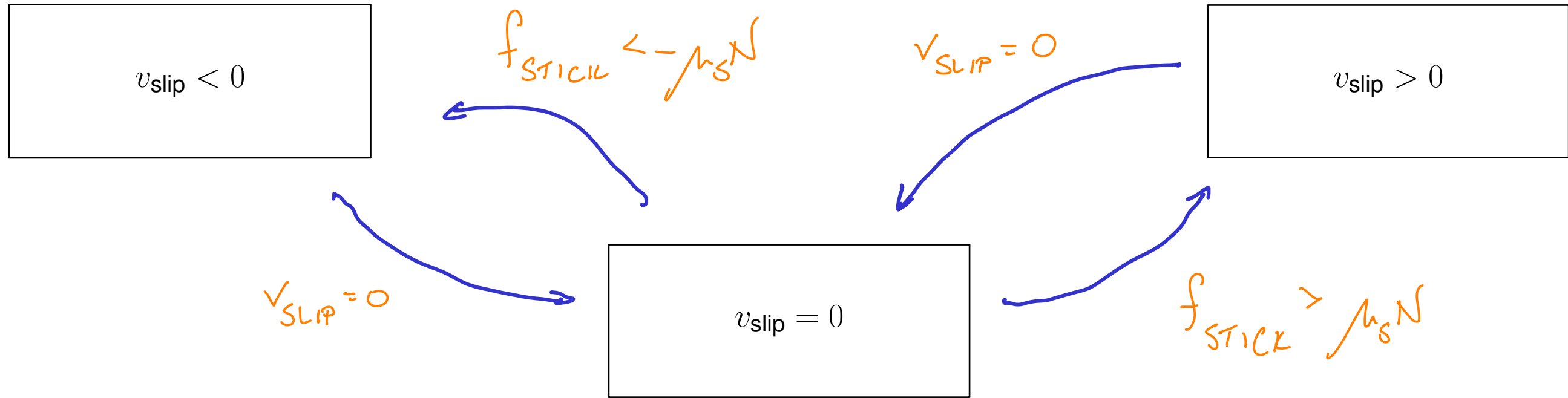
$$f_{\text{STICK}} = f_{\text{STICK}} \hat{e}_t \quad \text{STICKING FORCE}$$

$$f_r = \begin{cases} f_{\text{STICK}}, & v_{\text{SLIP}} = 0 & |f_{\text{STICK}}| \leq \mu_s N \\ -\mu_k N \left(\frac{v_{\text{SLIP}}}{|v_{\text{SLIP}}|} \right), & |v_{\text{SLIP}}| \neq 0 & \text{SLIP DIRECTION} \end{cases}$$

μ_s : STATIC COEFFICIENT OF FRICTION

μ_k : DYNAMIC (KINETIC) COEFFICIENT OF FRICTION





Handwritten equation defining the range of static friction force:

$$-\mu_s N < f_{stick} < +\mu_s N$$

