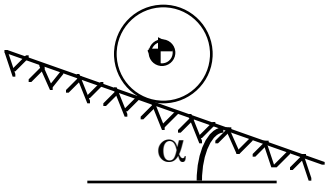
Sustained flows require variable friction

inclination α, basal shear stress S and normal stress N, effective friction μ_{eff}, "static" friction μ_E, collisional friction μ_I

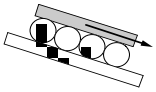
For steady, fully-developed flows:

$$\tan\alpha = S/N = \mu_{eff}$$

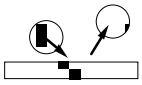
Forces acting on the flow are exerted at the contact with the base:



We have measured two kinds of friction coefficients:

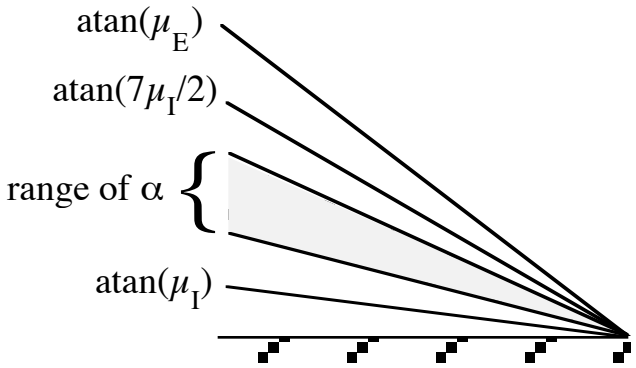


$\mu_E = 0.593$



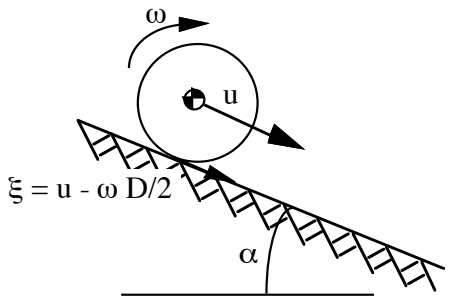
$\mu_I = 0.141$

The contact friction coefficient μ cannot be unique:



Modeling friction and stresses at the base

Enduring (long-lasting) contacts:

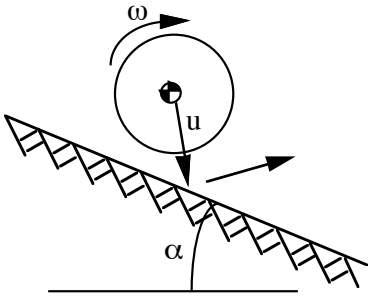


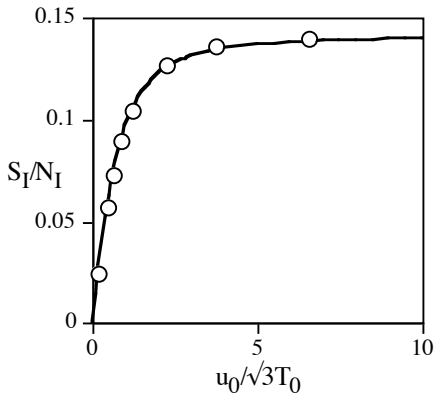
$$\frac{d\xi}{dt} = g\cos\alpha\,(\tan\alpha - \frac{7}{2}\,\mu) < 0 \text{ with } \tan\alpha < \frac{7}{2}\mu_I$$

$$\Rightarrow \xi \to 0 \;\Rightarrow\; \mu \to \mu_E$$

$$S_E/N_E = \mu_E$$

Impulsive (collisional) contacts:





$$S_I/N_I = f(u_0/\sqrt{3T_0}) \le \mu_I$$

from collisional granular theory and numerical simulations

Overall

$$S = S_I + S_E \qquad N = N_I + N_E \qquad S/N = \mu_{eff}$$