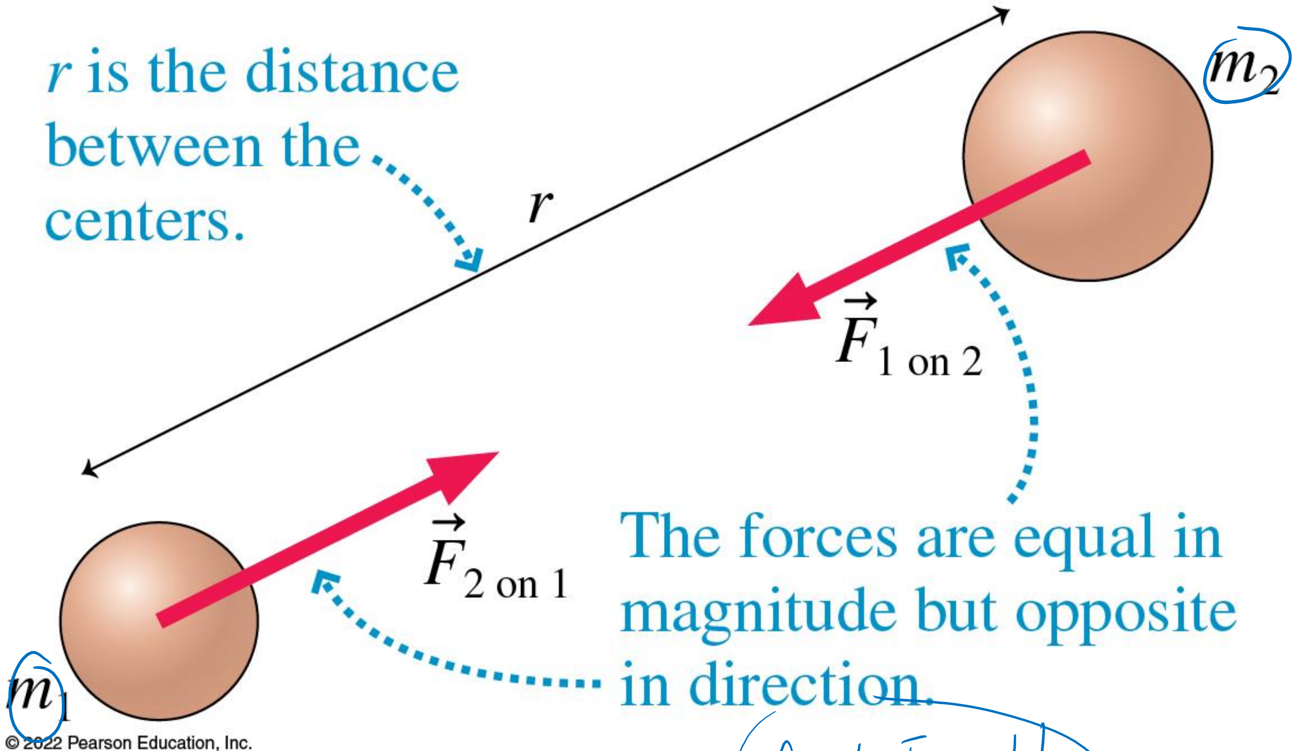
Chapter 6 – Dynamics: Motion Along a Line

- Mass/Weight/Gravity
- Friction forces
- Drag forces



$$F = G\frac{m_1 m_2}{r^2}$$

$$F_g = \frac{GM_E}{(R_E+h)^2}\,m = \frac{GM_E}{R_E^2(1+h/R_E)^2}\,m = \frac{GM_E}{R_E^2}\,m\left(1+\frac{h}{R_E}\right)^{-2}$$

$g \leftarrow \frac{GM_E}{R_E^2}$

flat Earth

$R_E \to \infty$

$h/R_E \to 0$

$h=0 \to F_g = mg$

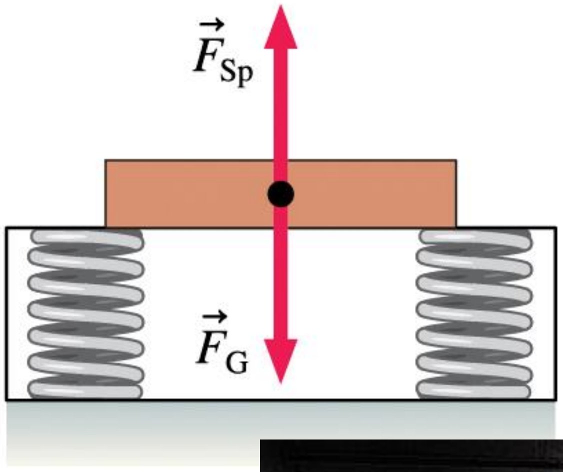
$$\frac{d_{Moon}}{R_E} \sim 60$$

$$a_{Moon} = \omega^2 d_{Moon} = g/(60)^2$$

What are mass and weight?

Mass and weight are not the same.

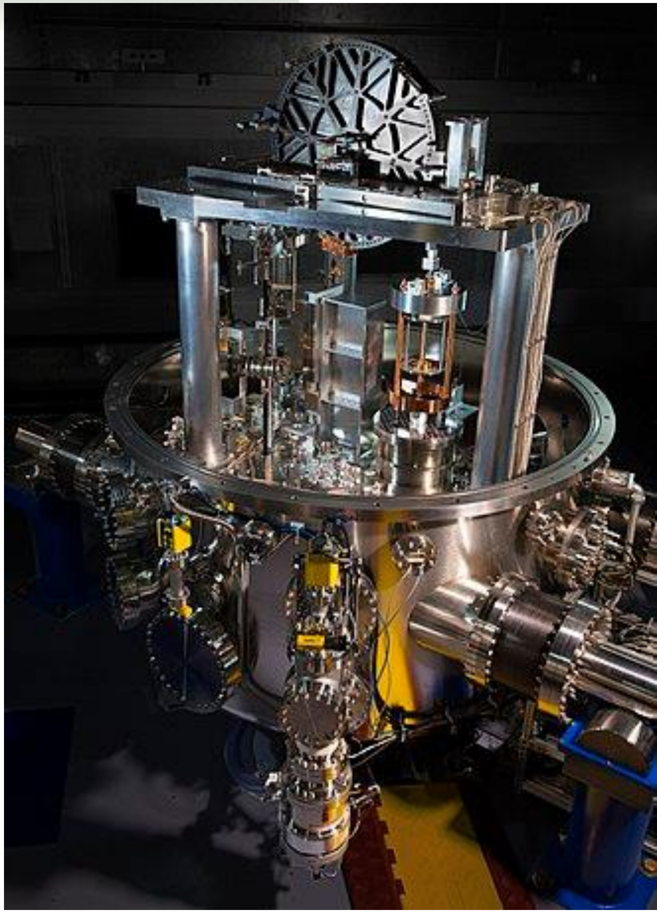
- **Mass** describes an object's inertia. Loosely speaking, it is the amount of matter in an object. It is the same everywhere.
- **Gravity** is a force.
- **Weight** is the result of weighing an object on a scale. It depends on mass, gravity, and acceleration.



$$m_i \to \vec{a} = \frac{1}{m_i}\sum \vec{F}$$

$$m_g \to F_g = \frac{G M m_g}{r^2}$$

$m_i = m_g$ to 1 in 10^{13}



https://commons.wikimedia.org/wiki/File:NIST-4_Kibble_balance.jpg

MODEL 6.3

Friction

$f_s \leq \mu_s n$

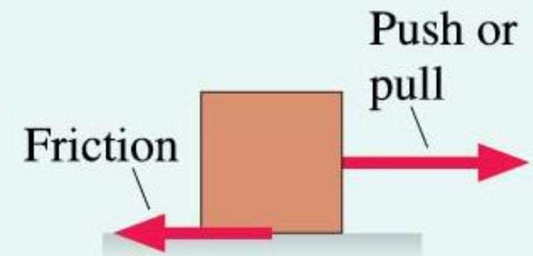
The friction force is *parallel* to the surface.

- ? Static friction: Acts as needed to prevent motion. Can have *any* magnitude up to $f_{s\,max} = \mu_s n$.
- Kinetic friction: Opposes motion with $f_k = \mu_k n$.
- Rolling friction: Opposes motion with $f_r = \mu_r n$.

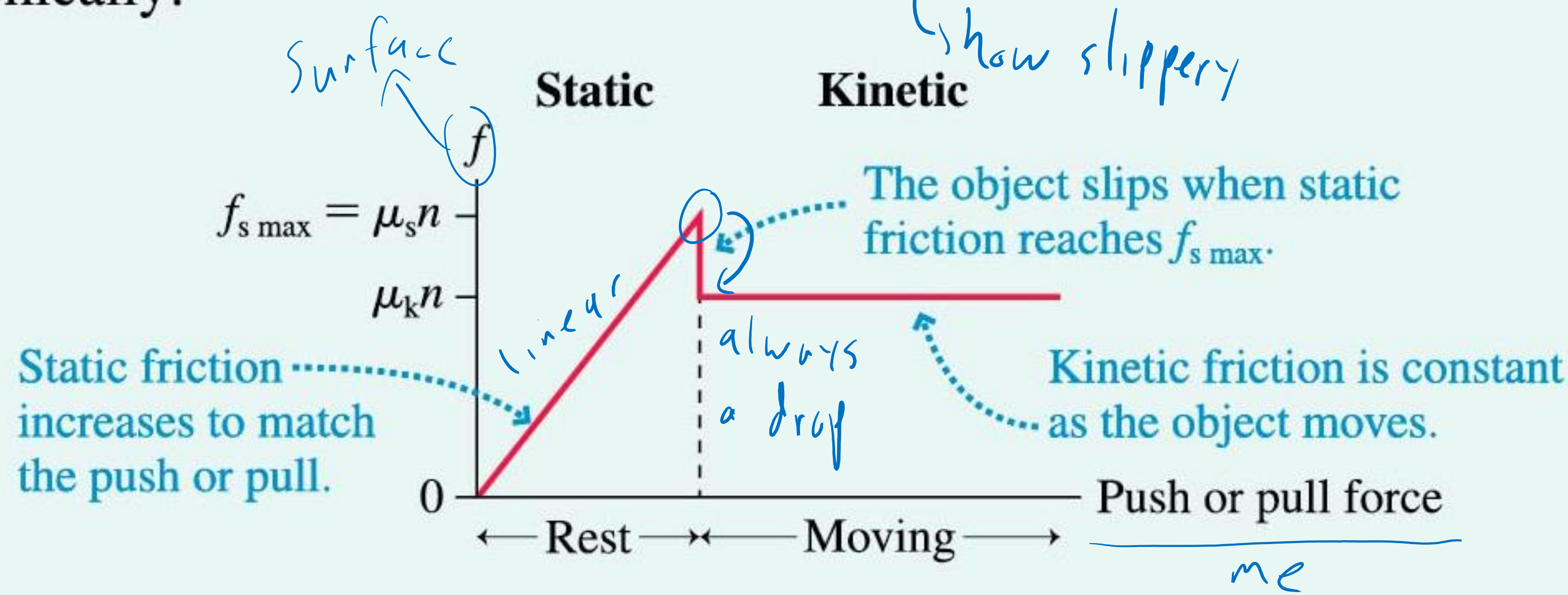
squeeze

show slippery

- Graphically:



Motion is *relative to the surface.*



$$Re = \frac{\text{inertial forces}}{\text{viscous forces}} = \frac{\rho v L}{\eta}$$

$$\vec{F}_{\text{drag}} = \left(\tfrac{1}{2} C_d \rho A v^2, \text{ direction opposite the motion}\right)$$

Re > 1

viscosity

$$(\vec{F}_{\text{drag}})_{\text{sphere}} = (6\pi\eta r v, \text{ direction opposite the motion})$$

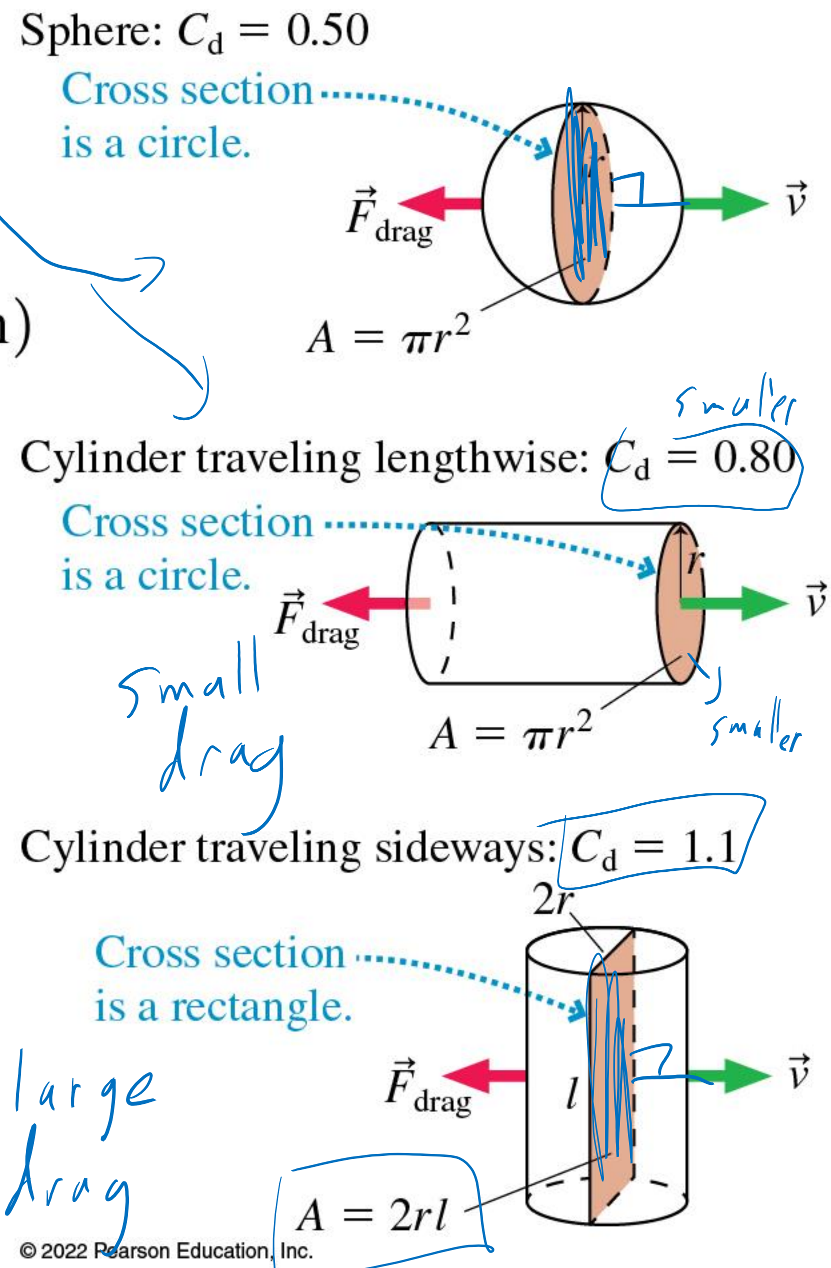
Re < 1

density

air/water

TABLE 6.3 Drag coefficients

Object	C_d
Commercial airliner	0.024
Swimming fish	0.15
Toyota Prius	0.24
Pitched baseball	0.35
Racing cyclist	0.88
Running person	1.2



terminal $|\vec{F}_{drag}| = |\vec{F}_g|$