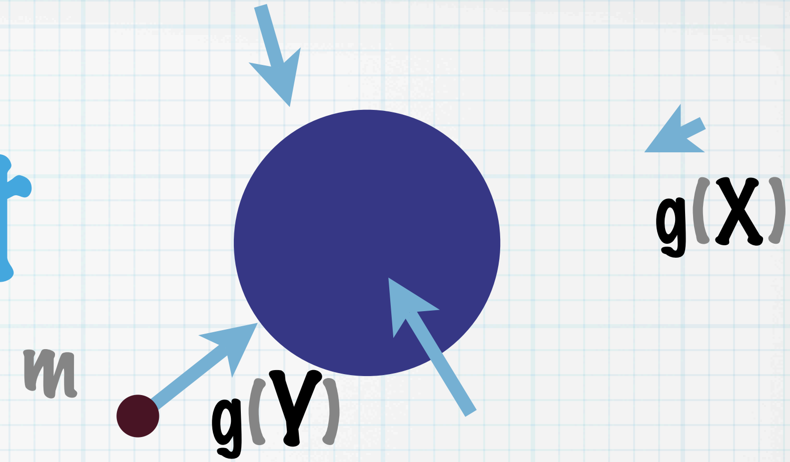
Dynamics I

Motion along a line

Weight

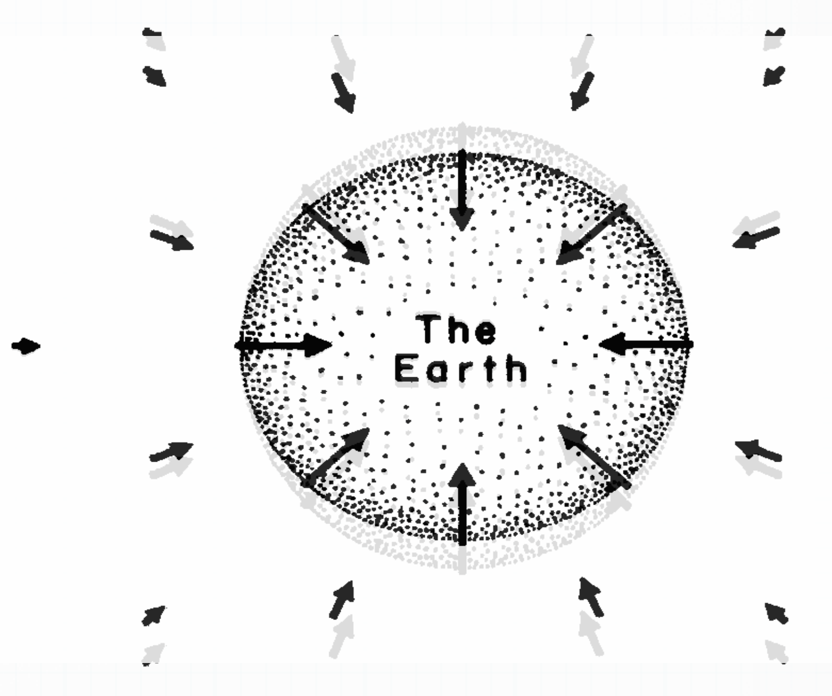


* The earth pulls all objects towards its centre.
* The force is its weight, $\mathbf{F}_{grav}$, or **w**. It depends on
  1. m, the object's mass (doesn't depend on location)
  2. $\mathbf{g}(\mathbf{r})$, the gravitational strength where it is
* $\mathbf{F}_{grav} = m\,\mathbf{g}(\mathbf{r})$
* Thus if we know $\mathbf{g}(\mathbf{r})$ at a location **X** and we know m of an object at **Y**, we can predict the object's weight at **X**.

g at different places

Gravitational Field of the Earth

PLACE	LATITUDE	ALTITUDE, METERS	MAGNITUDE OF THE FIELD, NEWTONS/KG
North Pole	90°	0	9.832
Greenland	70°	20	9.825
Stockholm	59°	45	9.818
Brussels	51°	102	9.811
Banff	51°	1376	9.808
New York	41°	38	9.803
Chicago	42°	182	9.803
Denver	40°	1638	9.796
San Francisco	38°	114	9.800
Canal Zone	9°	6	9.782
Java	6° South	7	9.782
New Zealand	37° South	3	9.800

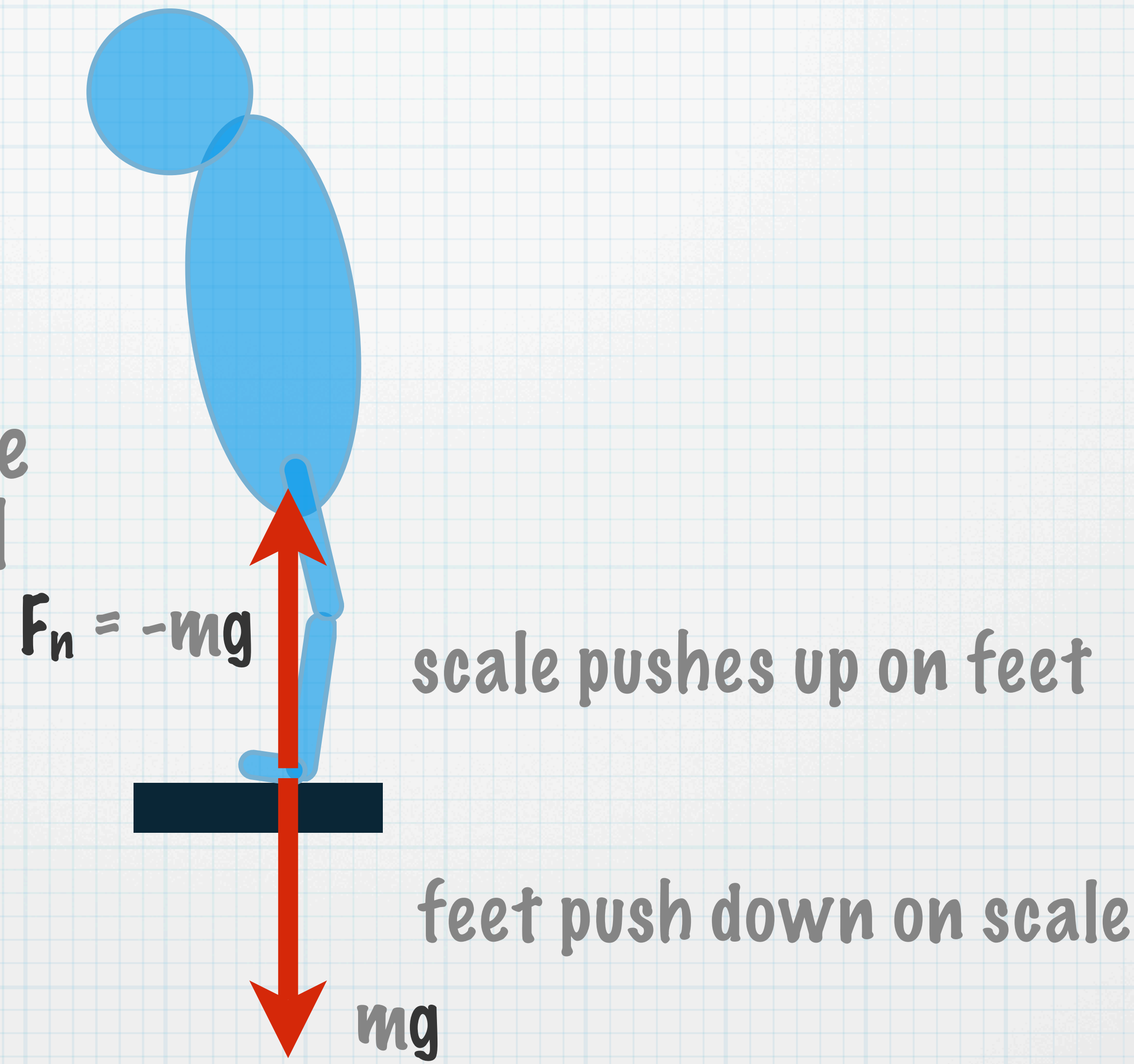


g is not uniform because earth is not spherical and it rotates

How scales weigh

equilibrium

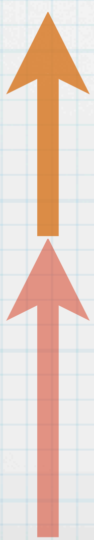
- A scale reads the magnitude of the normal force.

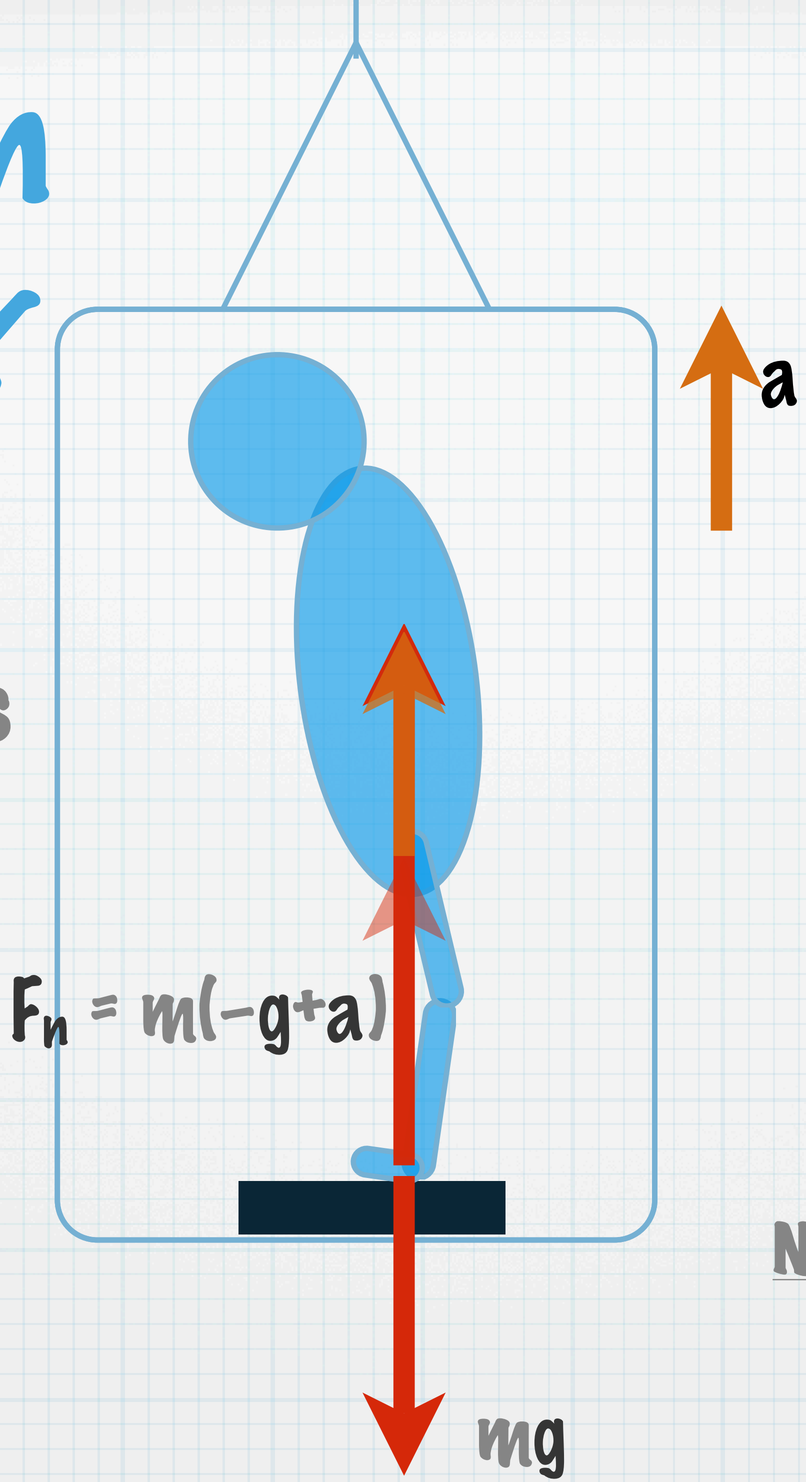


Scales in elevator

not equilibrium

- If an elevator acceleration is upward, the scale reads more.
- Apparent weight is m(g+a)





Note on conventions:

g is 9.8 m/s^2

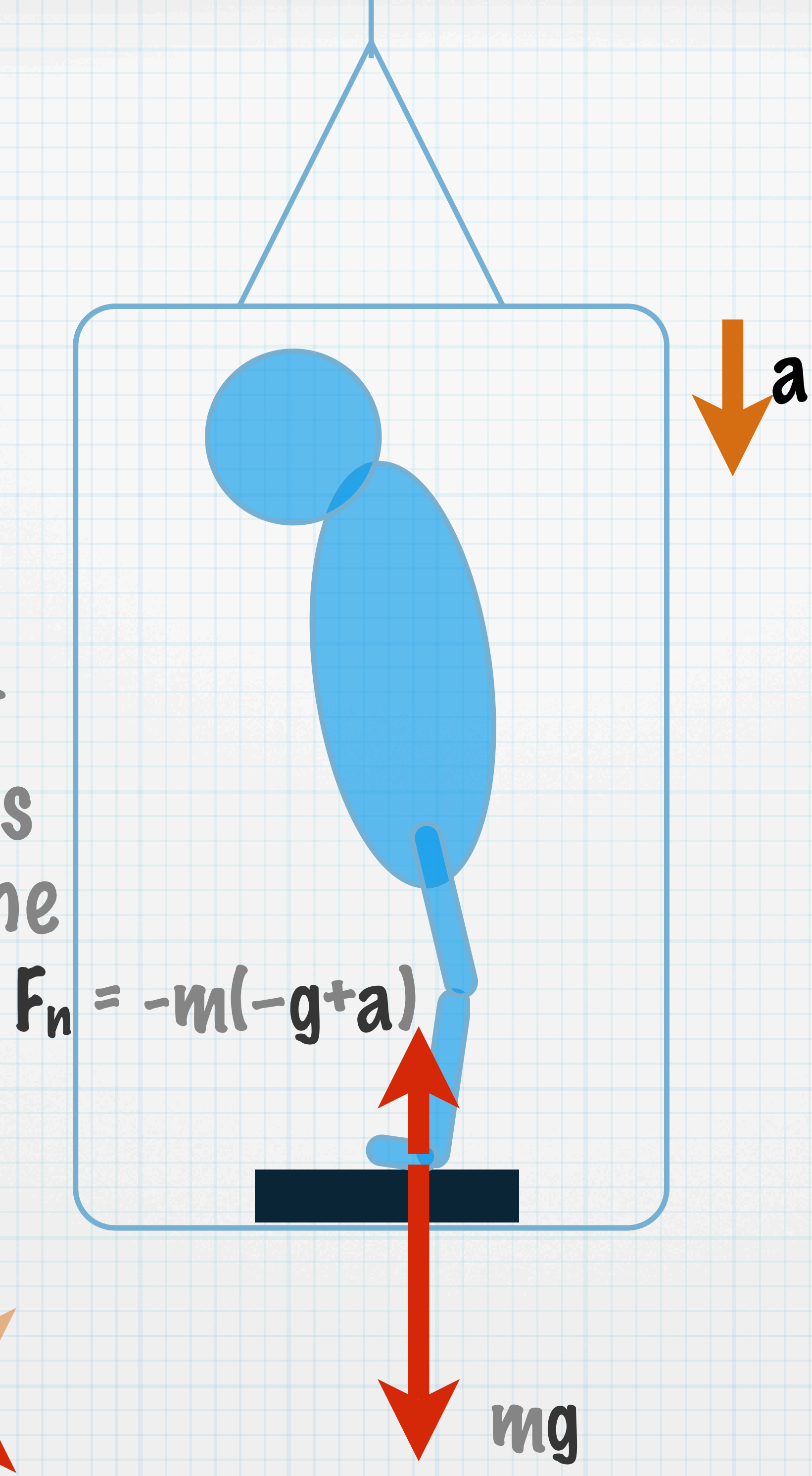
g is 9.8 m/s^2, down

-**g** is 9.8 m/s^2, up

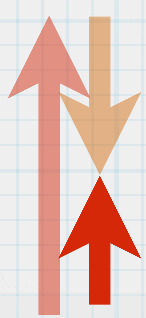
a is up or down, look at the arrow

Scales in elevator

not equilibrium



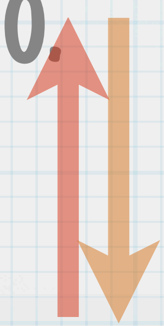
- If an elevator acceleration is downward, the scale reads less.
- Apparent weight is m(g-a).

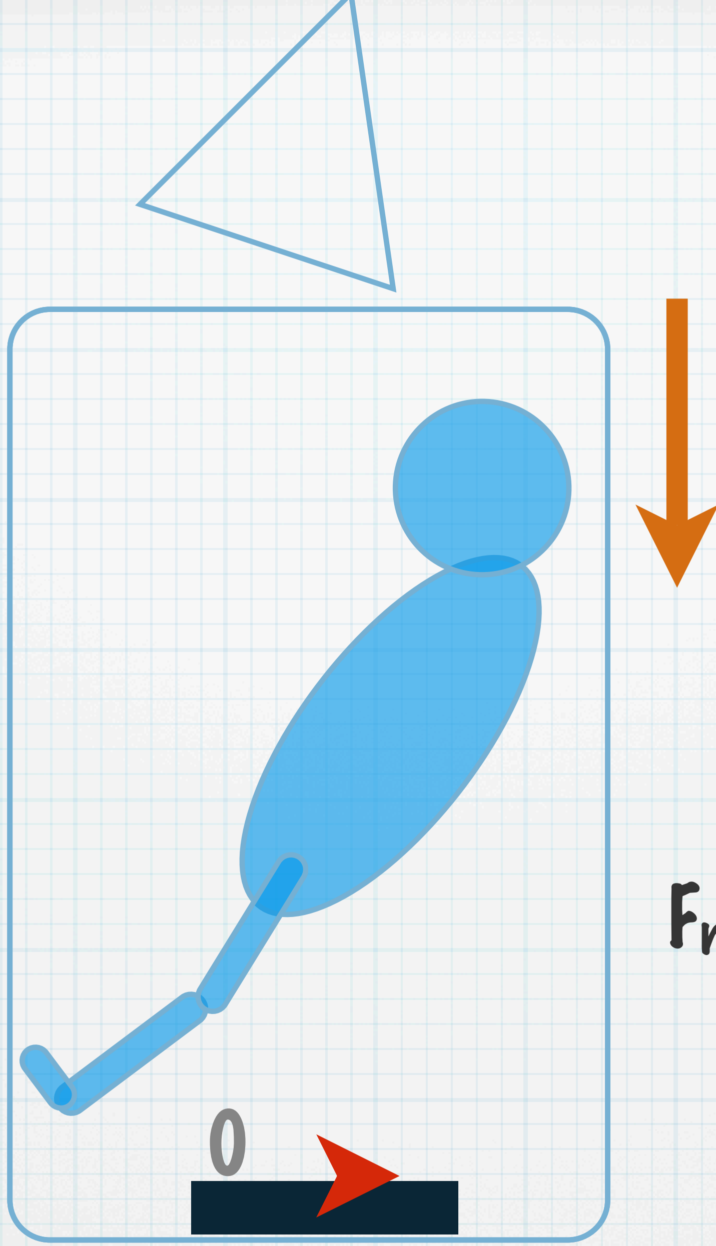


Free Fall

not equilibrium

* If an elevator is in free fall.
* Apparent weight is 0.

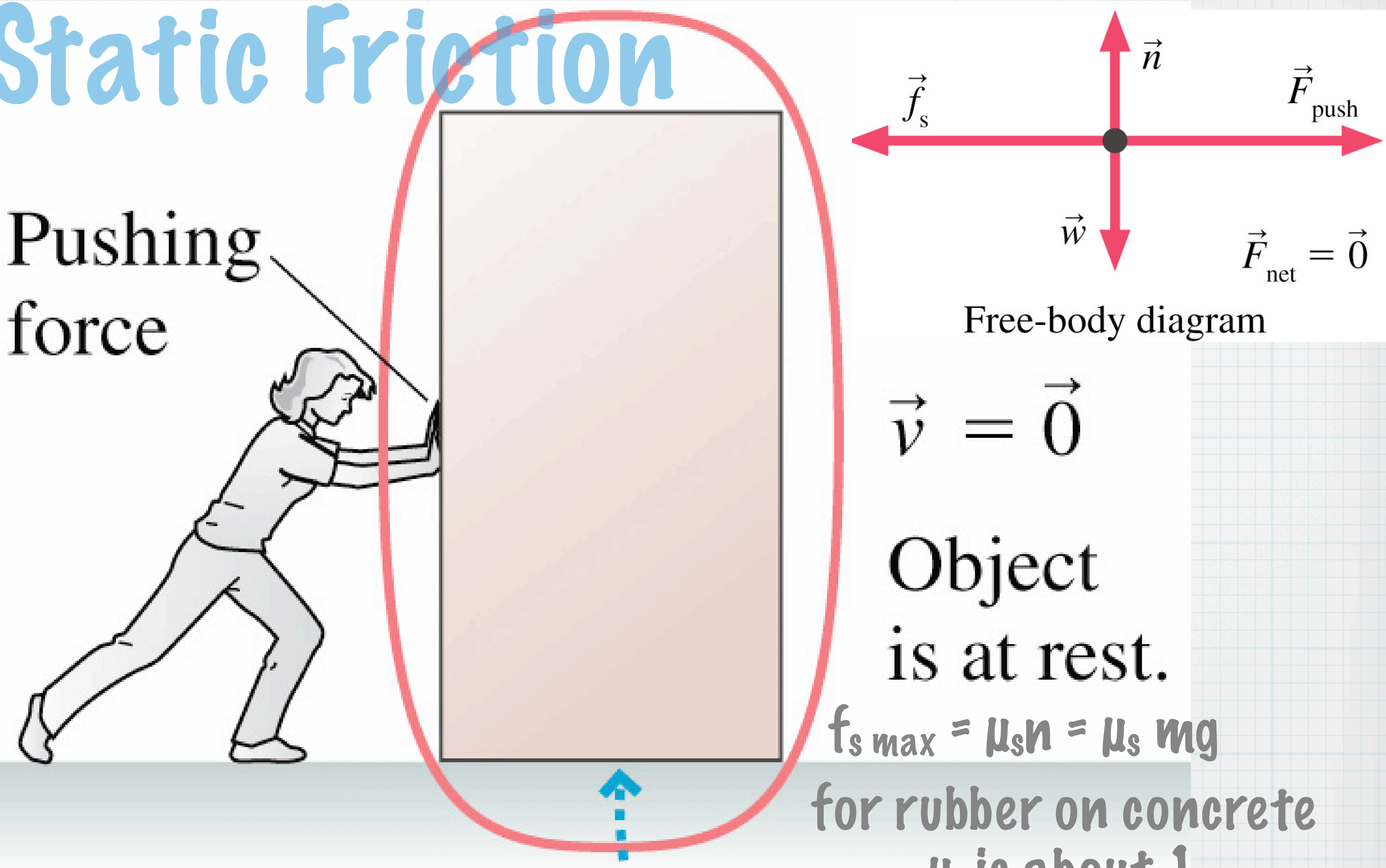




$F_n = -m(-g+g) = 0$

Our friend is weightless!

Static Friction



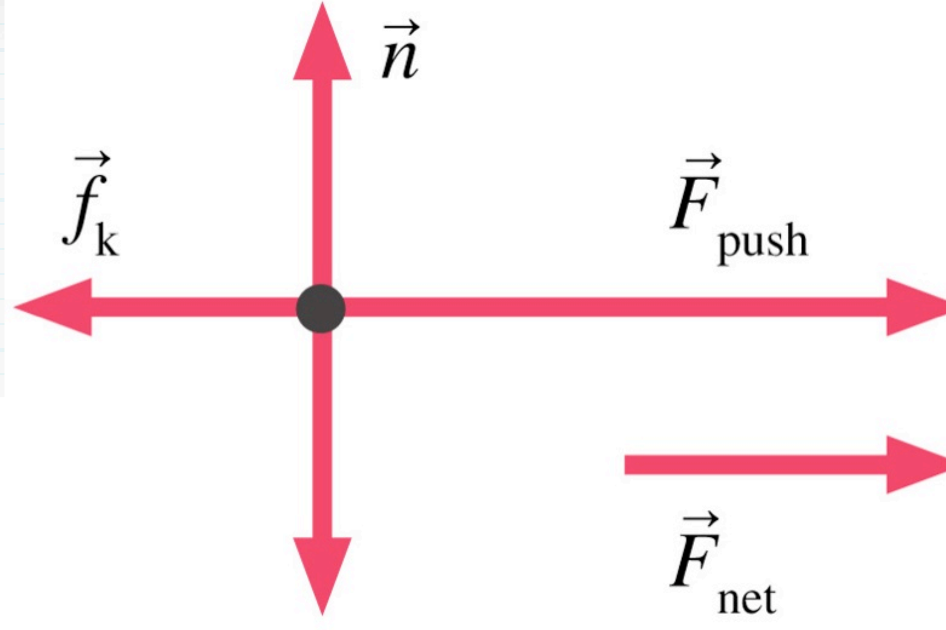
$f_{s\,max} = \mu_s n = \mu_s mg$

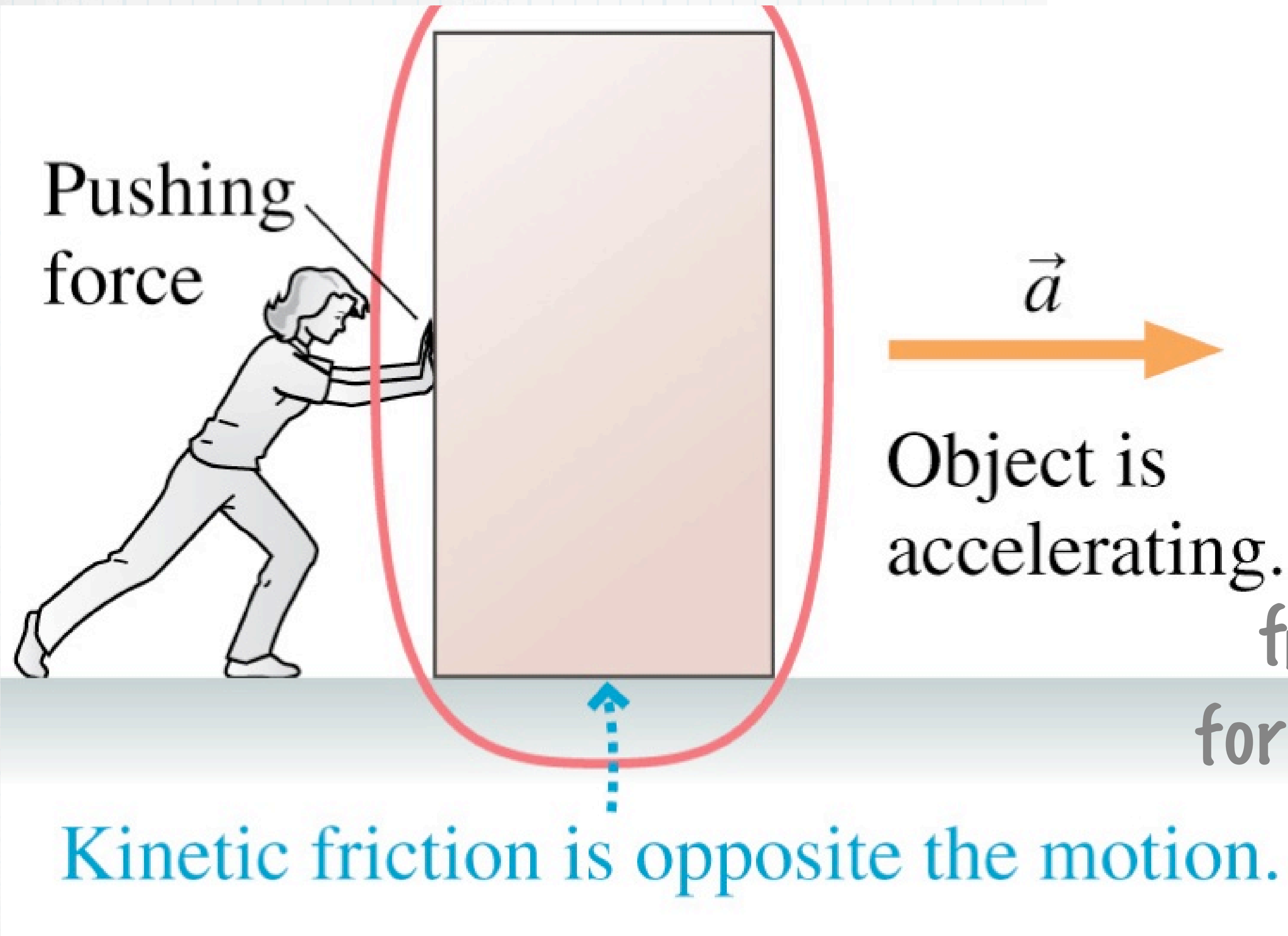
for rubber on concrete

μ_s is about 1

Static friction is opposite the push to prevent motion.

Kinetic Friction

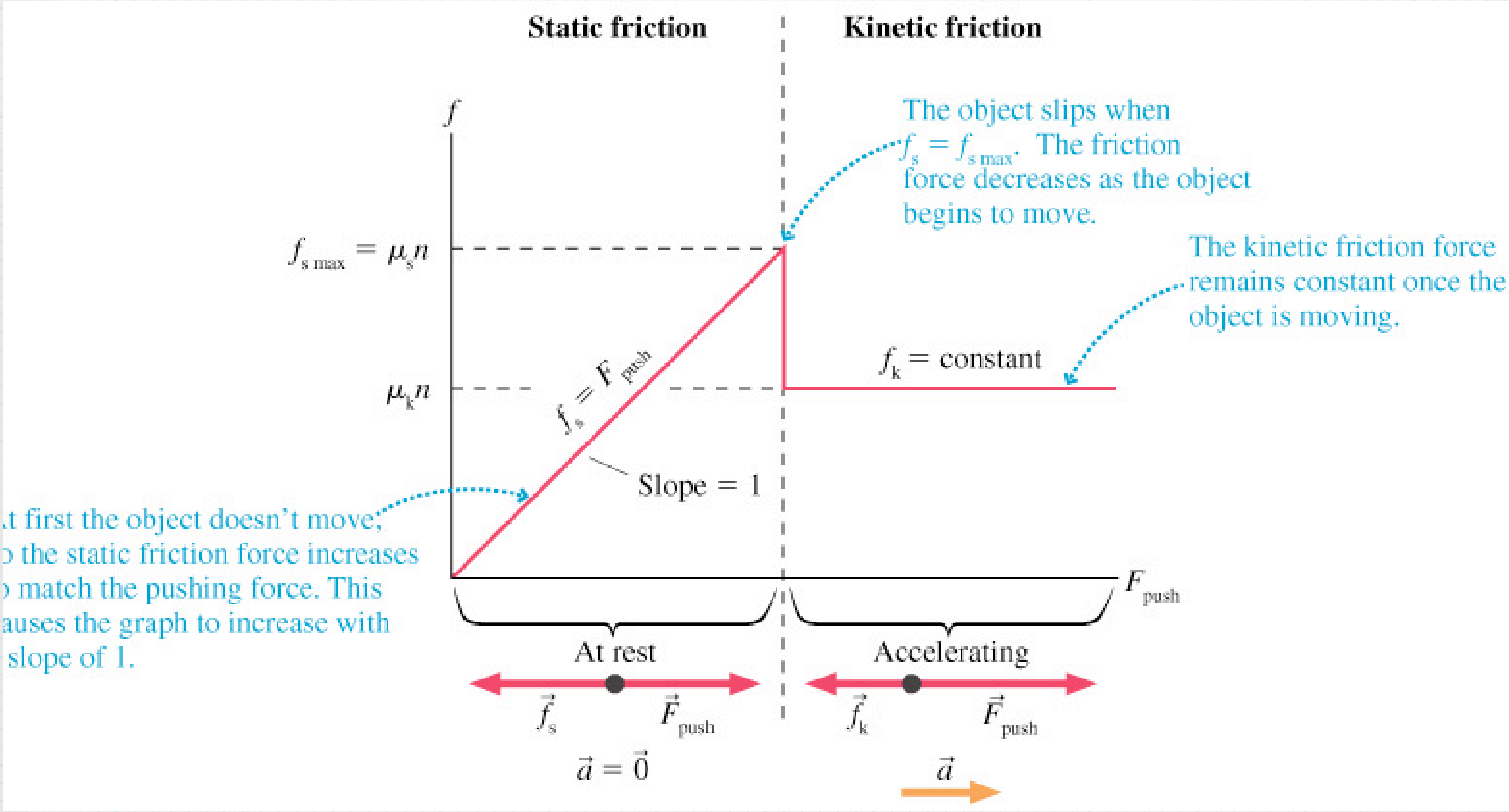




$f_k = \mu_k n = \mu_k mg$

for rubber on concrete μ_k is about 0.8

Static Friction • Kinetic Friction



Drag

Not your normal force!

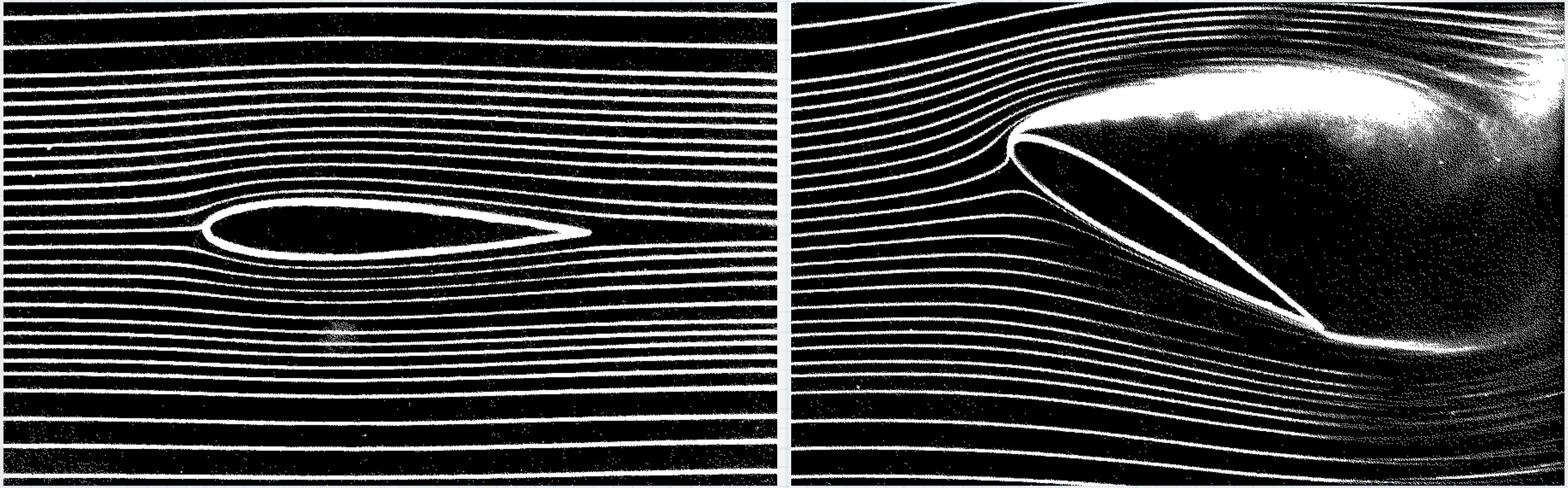


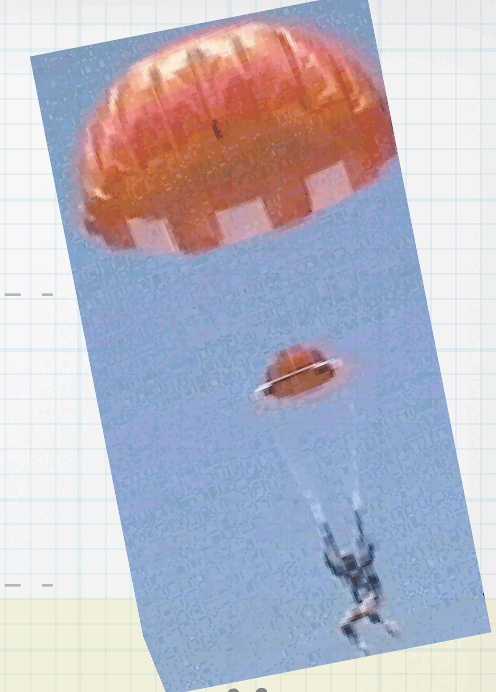
Figure 2 (a) Laminar flow **(b)** Turbulent flow
Pictures from *Shape and Flow* by Ascher Shapiro , Science Study Series #S21.

$D \approx k v$

$D \approx k v^2$

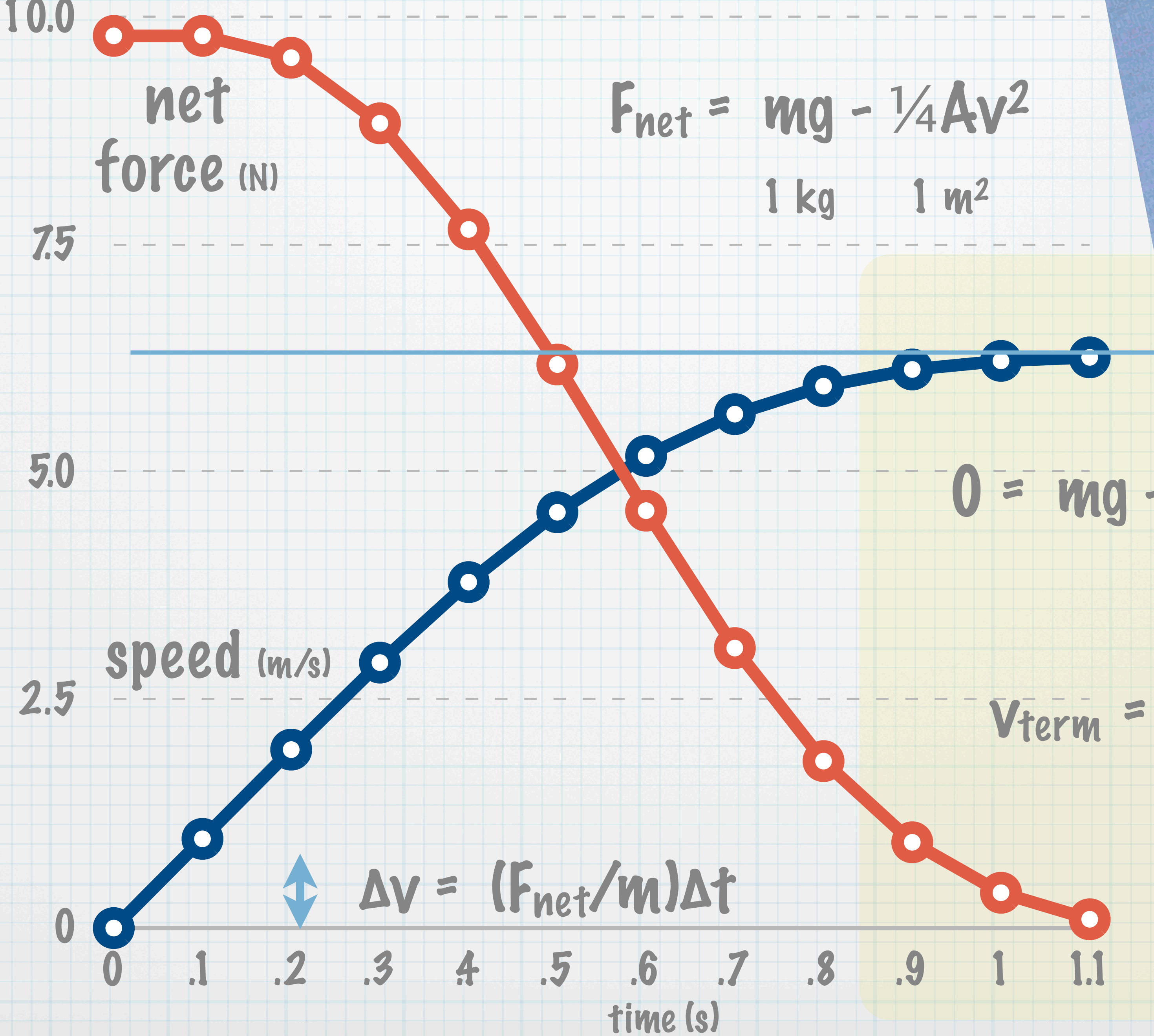
in air: $D \approx \frac{1}{4} A v^2$

Terminal Speed



$F_{net} = mg - \frac{1}{4}Av^2$

1 kg 1 m²



$\Delta v = (F_{net}/m)\Delta t$

$0 = mg - \frac{1}{4}A(v_{term})^2$

$v_{term} = \sqrt{4mg/A}$

6.3 m/s