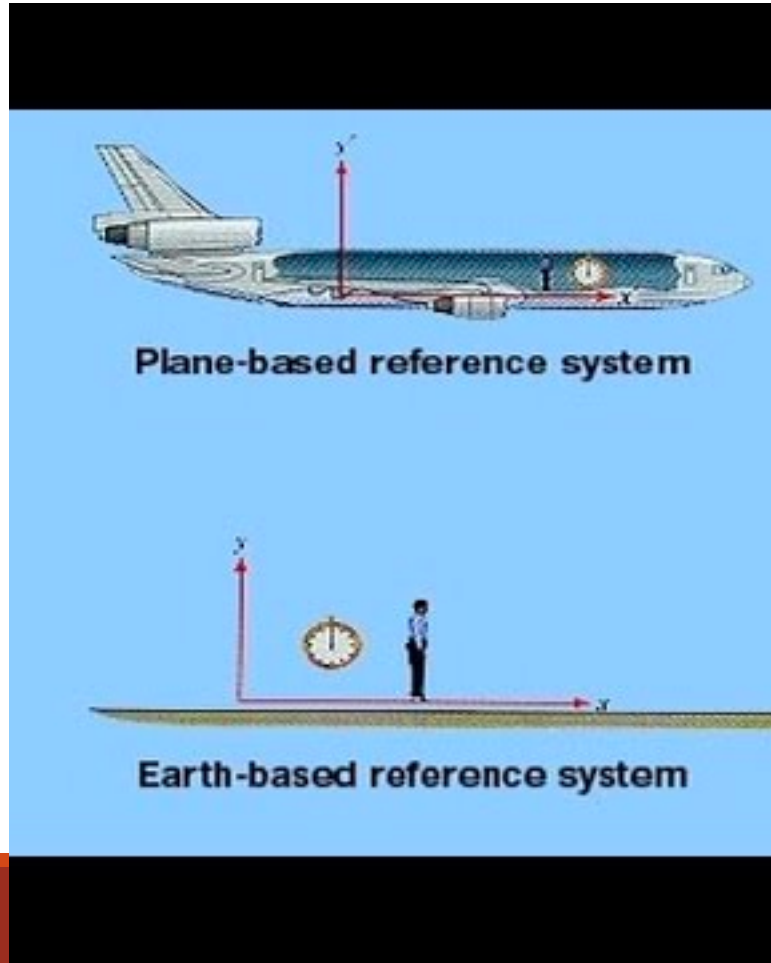
How are each of Newton's Laws represented?

Reference Frames

Newton's 1st Law is true only for **inertial reference frames**

If the frame of reference is accelerating, it is a **non-inertial reference frame** and Newton's 1st Law no longer applies



Goals for today

- Learn how to draw a free body diagram, identify the forces acting on an object, and determine whether the forces are balanced or unbalanced
- Understand when the magnitude of the normal force is greater than the force of gravity
- Understand the relationship between friction force and normal force

Why do you feel heavier when you are in an elevator going up, and why do you feel lighter when the elevator is going down?

Free body diagrams (FBD) (”Force Diagrams”)

Represent object as a point

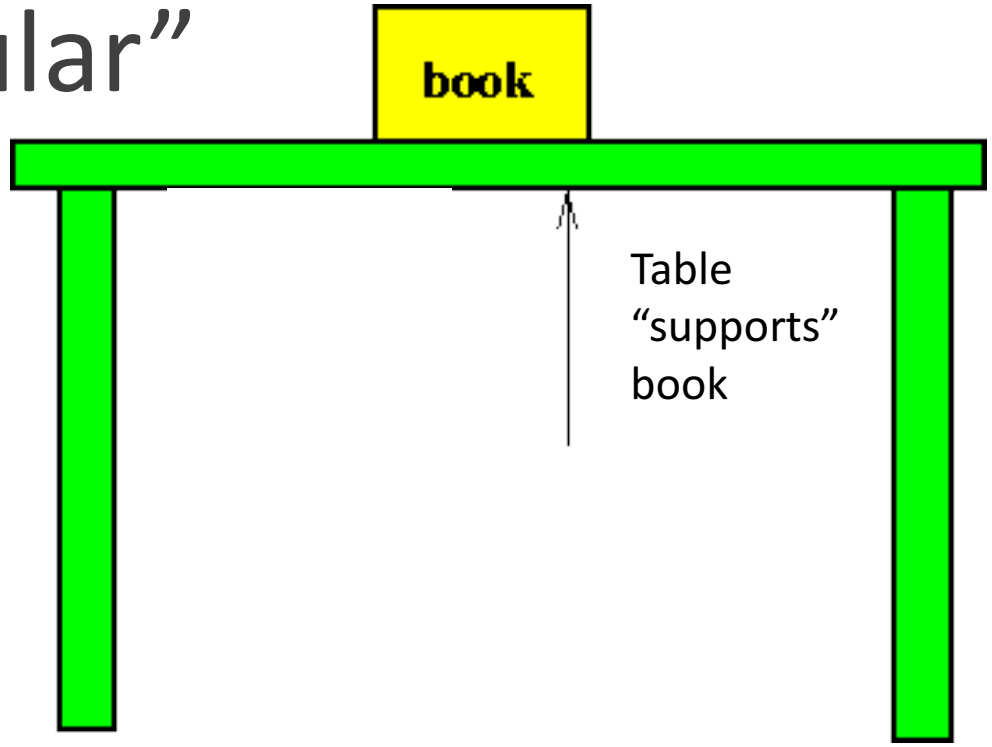
Draw all the forces acting on an object
- Think in terms of components!

Net force is the vector sum of all the forces
- Gravity (F_G)
- Direct push or pull (applied force F_{app})
- Friction (f_s or f_k)
- Tension (F_T): Strings, ropes, etc.
- Normal force (F_N)

Normal force

“Normal” means “perpendicular”

Support force



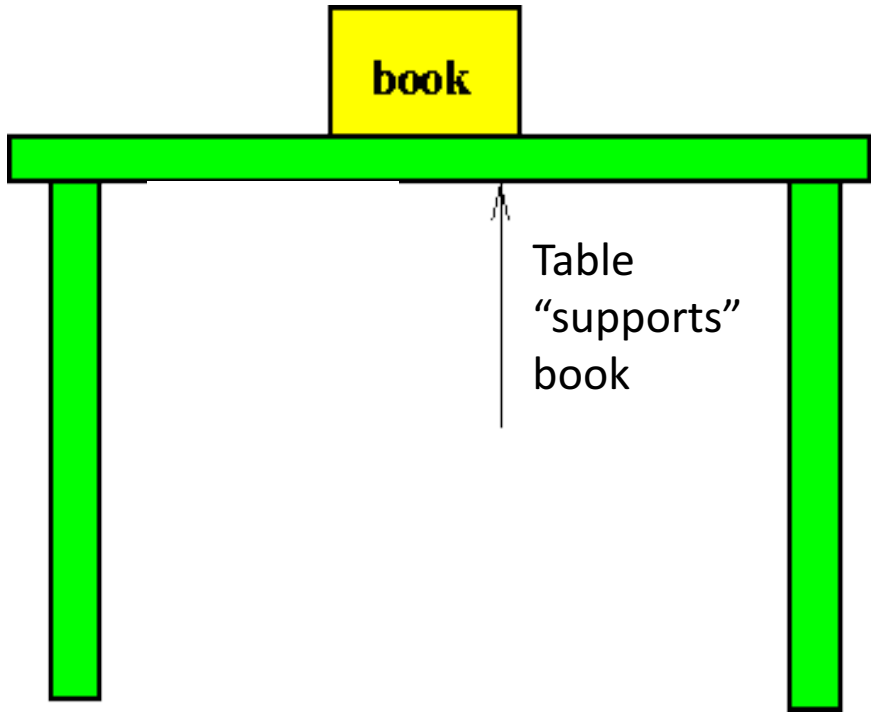
Finding the normal force

If the system is in equilibrium –

- Normal force keeps equilibrium in the direction **perpendicular to the surface**

Else:

- Use net acceleration/net force to find normal force



Normal force in an elevator

10 kg toddler in an elevator :

Elevator has 0 velocity and 0 acceleration

Sum $F_y = 0$, $F_N = F_G = 98.1N$

Elevator at constant velocity (0 acceleration)

Sum $F_y = 0$, $F_N = F_G = 98.1N$

2 m/s^2 acceleration

Sum $F_y = +20$ N

$F_N = 118.1N$

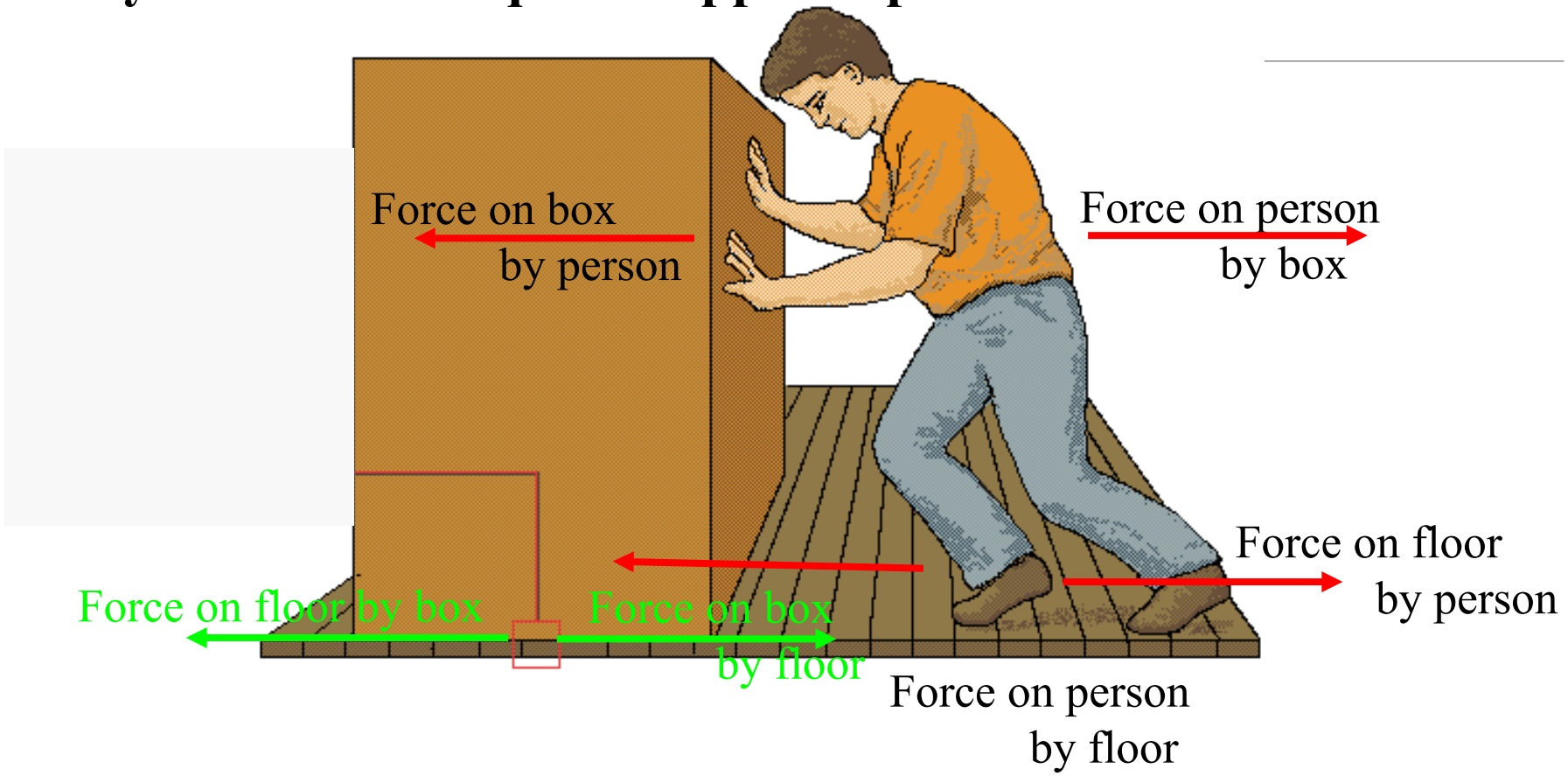
-2 m/s^2 acceleration

Sum $F_y = -20$ N

$F_N = 78.1N$

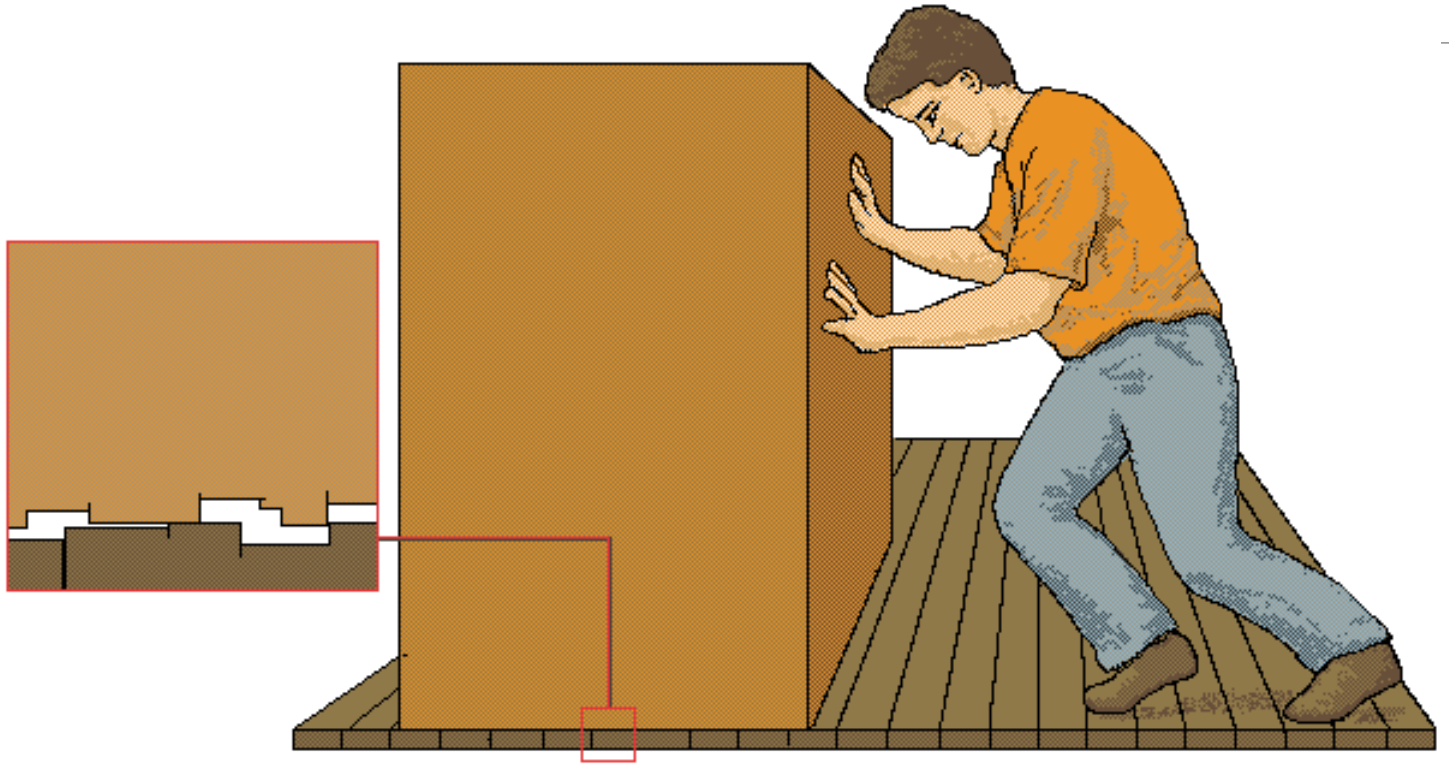
Friction is a Force

It's the sum of all the forces that determines the acceleration.
Every force has an equal & opposite partner.



Friction Mechanism

Corrugations in the surfaces grind when things slide.
Lubricants fill in the gaps and let things slide more easily.

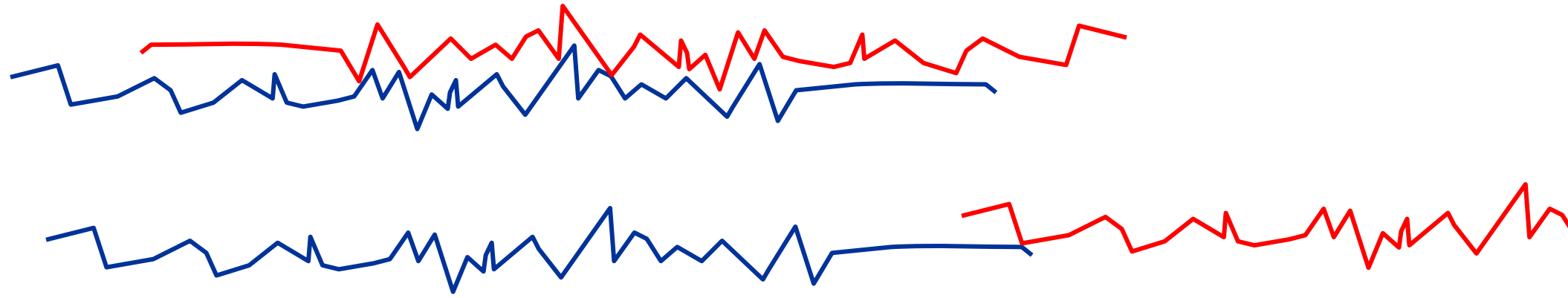


Static and Sliding (Dynamic) Friction

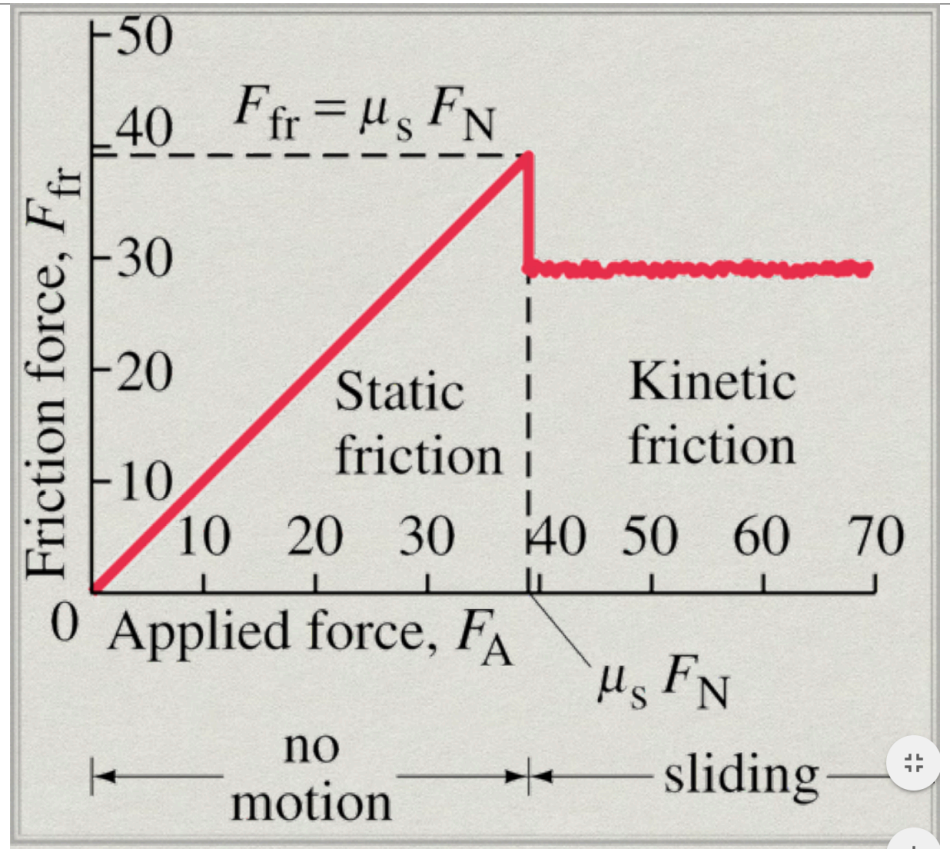
Static frictional force (f_s): in the direction to prevent sliding

Kinetic (sliding) frictional force (f_k): opposite the direction of sliding

Static frictional forces always greater than kinetic ones



Why friction force can't be more than the force of a pull



Friction Force = Normal Force × (coefficient of friction)

$$F_{friction} = \mu \cdot F_{normal}$$

Normal force and friction force are perpendicular to each other

$\mu_s > \mu_k$

$F_s < \mu_s F_N$: F_s will match force of the pull in order to keep object in static equilibrium

Maximum $F_{s\,max} = \mu_s F_N$: then the object "slips"