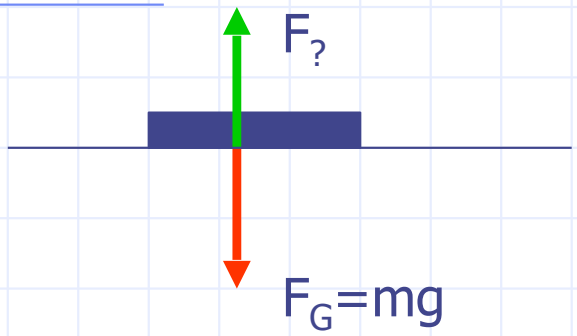
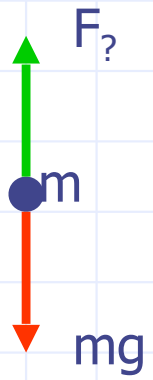
Chapter 4: Contact Interactions and Forces

The Normal Force

- Consider the textbook on the table





- Consider Newton's 2nd law in y-direction:

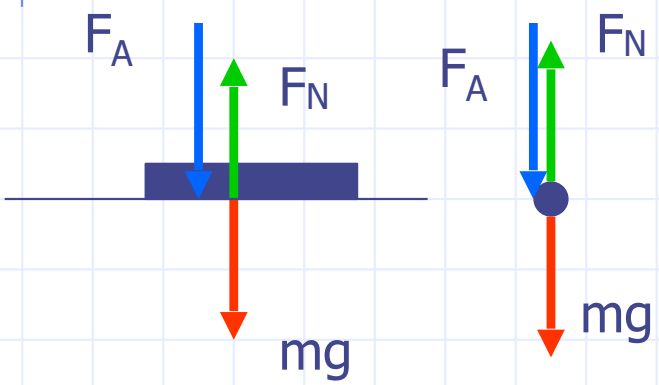
$$\sum F_y = F_? - mg = ma_y$$

but book is at rest. So, $a_y=0$, gives

$$\sum F_y = F_? - mg = 0 \rightarrow F_? = mg$$

New force has same magnitude as the weight, but opposite direction

- New force is a result of the contact between the book and the table
- New force is called the Normal Force, **n**, **N** or $\mathbf{F_N}$
- **In general it is not equal to mg**,
  - we must usually solve for $\mathbf{F_N}$
- ``Normal'' means ``perpendicular'' (to the surface of contact)
- Now, apply an additional force, F_A to the book



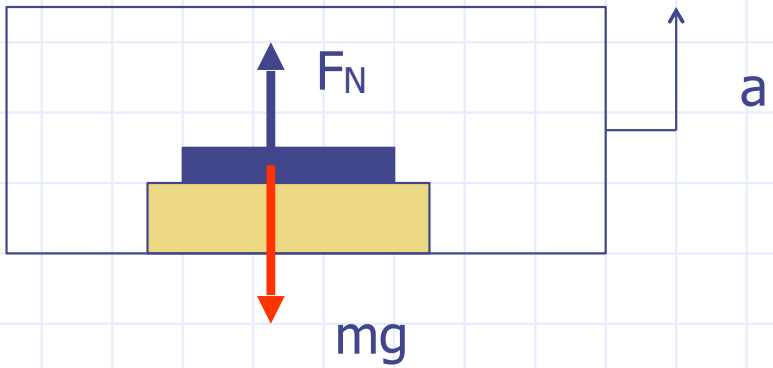
$$\sum F_y = F_N - mg - F_A = 0$$

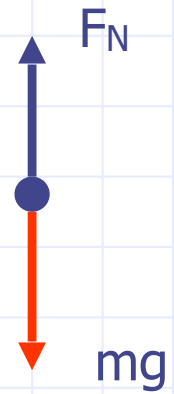
$$F_N = mg + F_A$$

The normal force is not mg!

Normal Force (Revisited)

- Put textbook on a scale in an elevator





- If elevator is at rest or moving with a constant velocity up or down, a=0. Then Newton's 2nd law gives:

$$\sum F_y = F_N - mg = 0 \quad \text{or} \quad F_N = mg$$

- If elevator is accelerating?

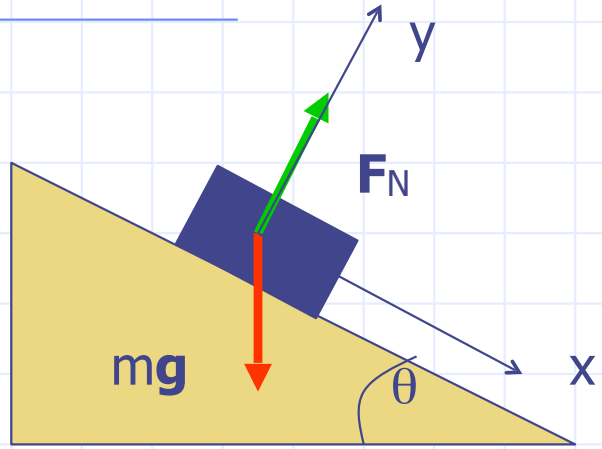
$$\sum F_y = F_N - mg = ma$$

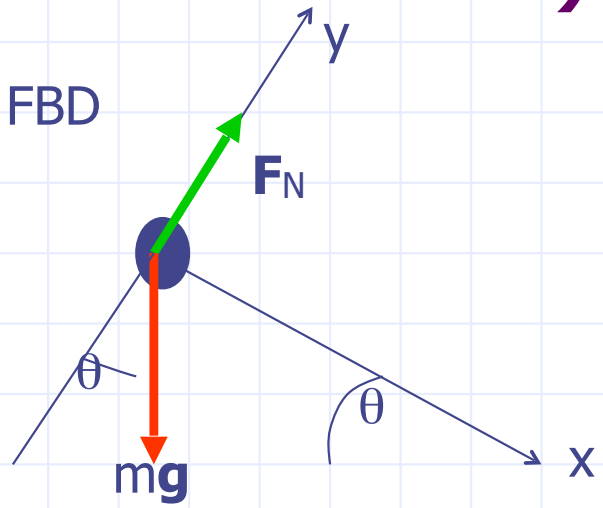
$$F_N = mg + ma$$

$$F_N = m(g + a)$$

  - If a > 0, F_N > mg
  - If a < 0, F_N < mg
  - If a = -g, F_N = 0 (“weightless”)

Book on an Incline (Frictionless)





- Using Newton's 2nd Law, find the normal force and the acceleration of the book
- As we did for 2D kinematics, break problem into x- and y-components

$$\sum F_x = ma_x \qquad \sum F_y = ma_y$$

$$mg\sin\theta = ma_x \qquad F_N - mg\cos\theta = 0$$

$$a_x = g\sin\theta \qquad F_N = mg\cos\theta$$

- If $\theta \to 0°$, $a_x = 0$ and $F_N = mg$
- If $\theta \to 90°$, $a_x = g$, $F_N = 0$

Frictional Forces

- Two types:
  - static – applies to stationary objects
  - kinetic – applies to sliding (moving) objects
- Like F_N, the Frictional Force is a contact force, but acts parallel to the interface of two objects