Newton's Laws

- **Newton's 1st Law (Same as Galileo's law of inertia): No force => no acceleration.**

"An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by a force."

$$\vec{F} = 0 \quad \Rightarrow \quad \vec{v} = const$$

Modern interpretation: "there exists a reference frame called inertial, in which the above statement is correct."

- **Newton's 2nd Law:** $\vec{F} = m\vec{a}$

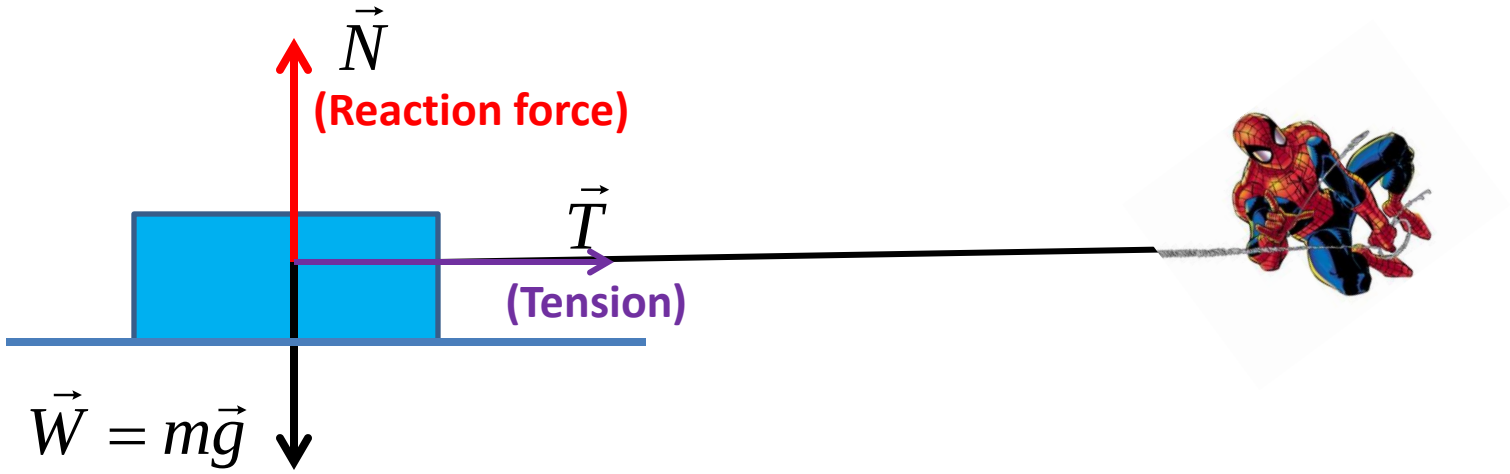
"Force equals mass times acceleration"

- **Newton's 3rd Law:** $\vec{F}_{B\to A} = -\vec{F}_{A\to B}$

"Any Force of action has an equal and opposite Force of reaction "

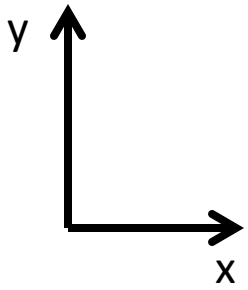
Unit of force is called Newton (N) $1N = 1\frac{kg \cdot m}{s^2}$

Examples of Forces



(Gravitational force , or Weight)

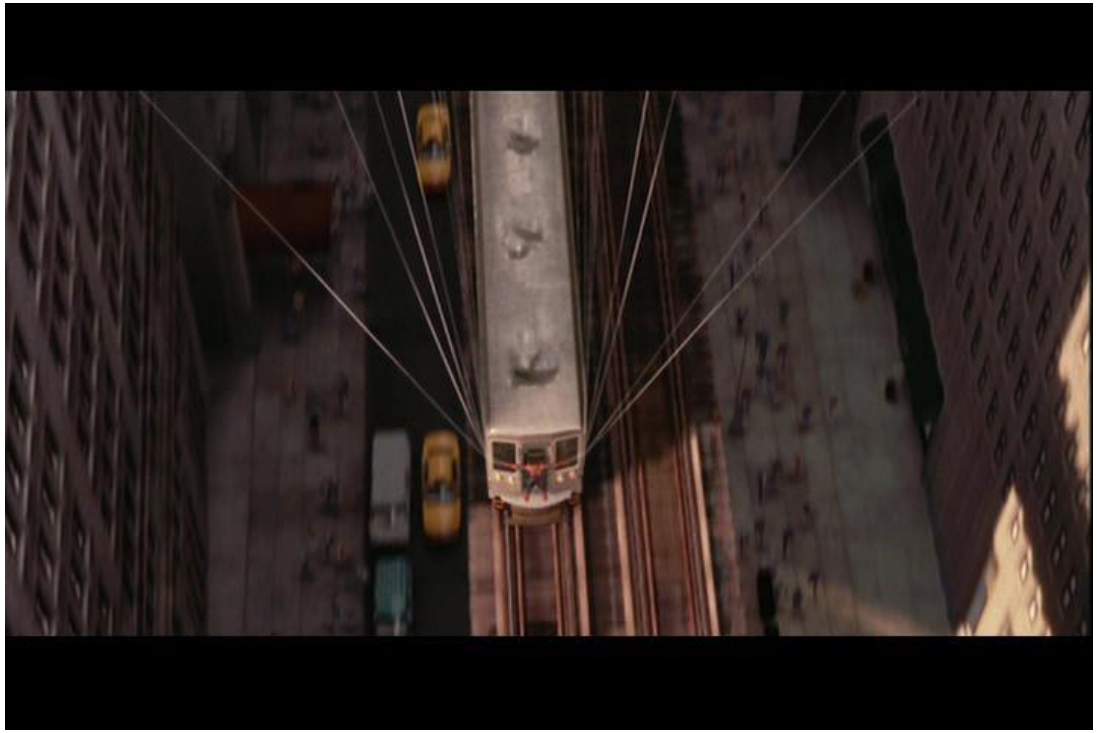
Forces a vectors! The total force is the *vector sum* of all applied forces:



$$\vec{F}_{total} = \vec{N} + \vec{T} + \vec{W}$$

$$\vec{F}_{total} = (F_x, F_y) = (T, N - mg)$$

Homework



Problem 1.

In the movie Spiderman 2, Peter Parker aka Spiderman manages to stop the train by using his web (search YouTube for "**Peter Stops The Train!"** clip). It takes t=45s of screen time. The initial speed of the train is approximately v=80 km/hr.

Find the average acceleration of the train, and the force that Spiderman can hold. This force is of strategic importance for any villain: you can see from the video that the superhero is close to his limit. Mass of the NYC subway train (full of people) is 300,000kg. How this force approximately compares to Spiderman's weight?

Problem 2.

The Apollo mission to the Moon was lunched by a very powerful rocket called Saturn V. The total mass of the rocket right before launch was $\boldsymbol{M=2.8x10^6\ kg}$. Total thrust (propulsion force) of 5 engines of the first stage is $\boldsymbol{F=34x10^6\ N}$ (Newtons). The rockets is launched vertically upward.

a) Find the ***total force*** acting on the rocket and acceleration of the rocket right after the launch. Neglect air resistance.
b) Similarly to part (a), find acceleration right before the fuel of the first stage is fully burned. The mass of the fuel is $\boldsymbol{m=2.1x10^6\ kg}$