

# Newton's Laws

- Newton's 1<sup>st</sup> Law (Same as Galileo's law of inertia): No force  $\Rightarrow$  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."*

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

- Newton's 2<sup>nd</sup> Law:

$$\vec{F} = m\vec{a}$$

*"Force equals mass times acceleration"*

- Newton's 3<sup>rd</sup> Law:

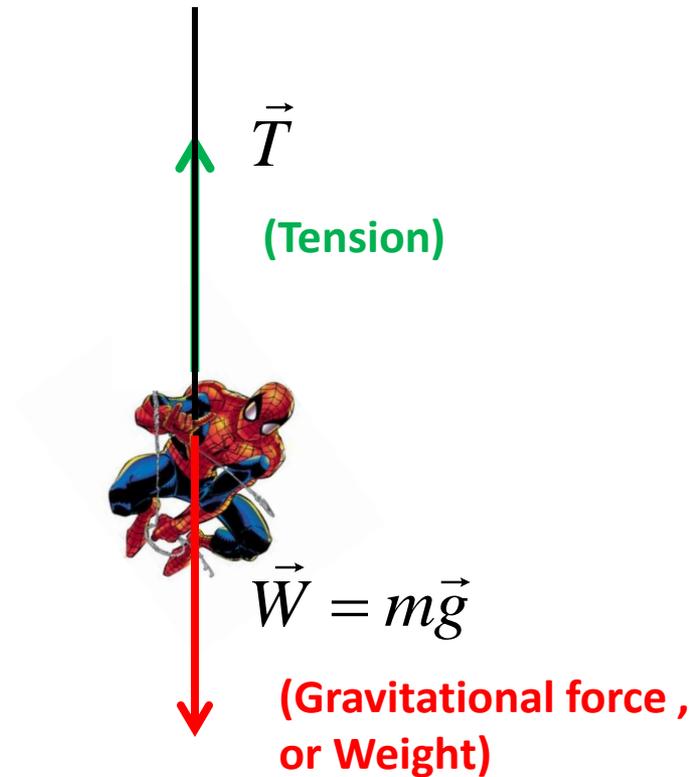
*"Any Force of action has an equal and opposite Force of reaction"*

$$\vec{F}_{B \rightarrow A} = -\vec{F}_{A \rightarrow B}$$

Unit of force is called Newton (N)

$$1N = 1 \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$$

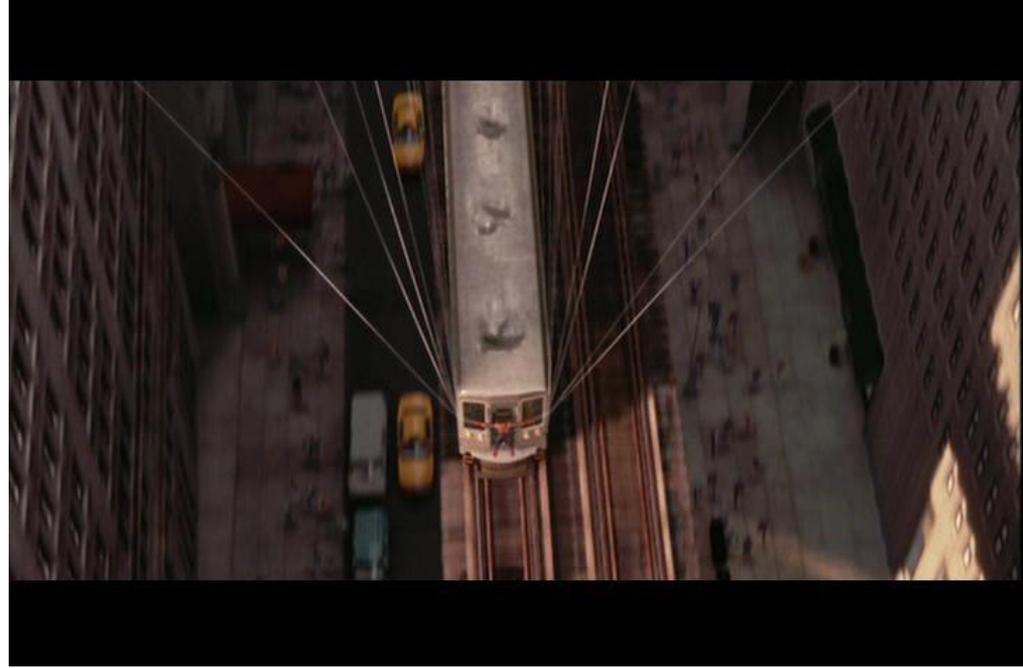
# Examples of Forces



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

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

# Homework



In the movie Spiderman 2, Peter Parker aka Spiderman manages to stop a train by using his web. (Search in YouTube for “**Peter Stops The Train!**” clip). It takes  $t=45\text{s}$  of screen time. The initial speed of the train is approximately  $v=80\text{ km/hr}$  (you’ll need to convert to  $\text{m/s}$ !).

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. The mass of the NYC subway train (full of people) is  $300,000\text{kg}$ .