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."

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

- **Newton's 2nd Law:**

"Force equals mass times acceleration"

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

- **Newton's 3rd Law:**

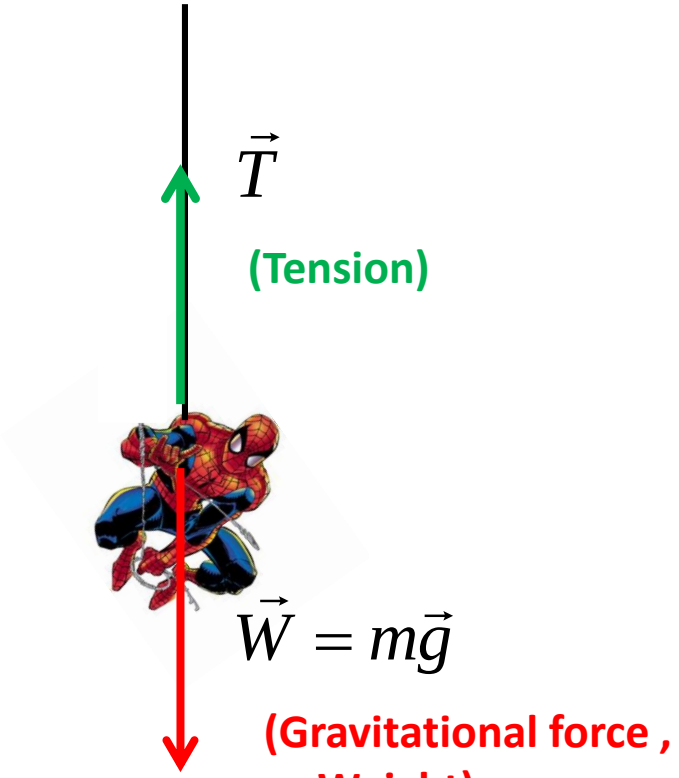
"Any Force of action has an equal and opposite Force of reaction "

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

Unit of force is called Newton (N)

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

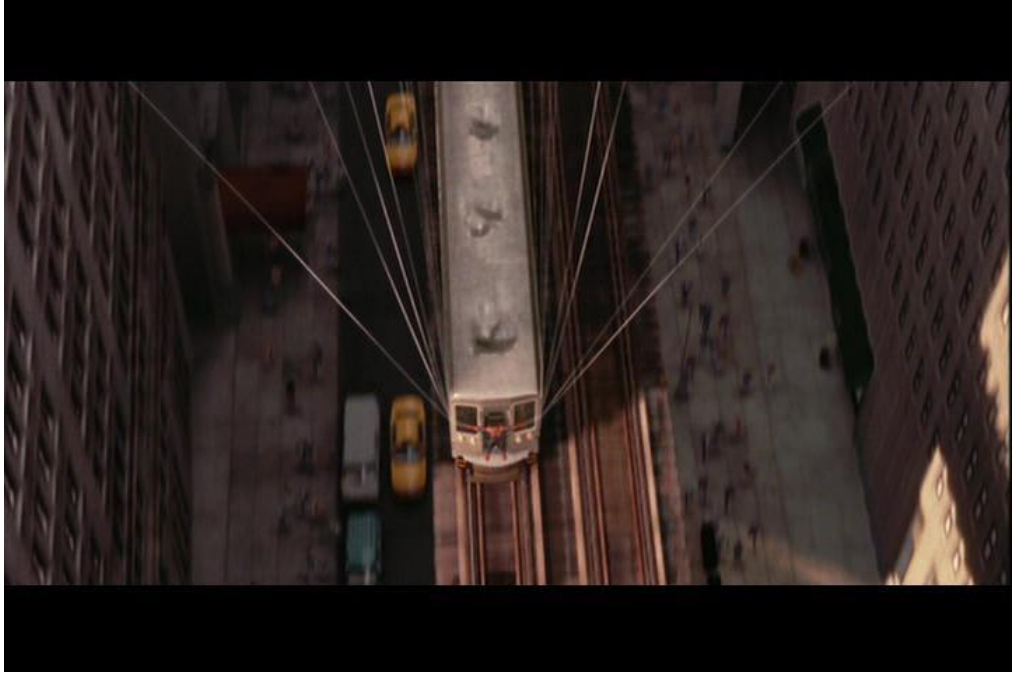
Examples of Forces



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

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

Homework



Problem 1

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=45s of screen time. The initial speed of the train is approximately v=80 km/hr (you'll need to convert to 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 300,000kg.

Homework

Problem 2

Redo Problem 2 from the previous homework (you can find it in the next page) and compare to the solution we found in class. Make sure to substitute the appropriate values to find a final answer.

TIP: Whenever you have the solution of a physics problem beforehand, it is a very good exercise to try to do the problem without looking at the solution. In this way, you will try realize what you understand and what you don't. If you get stuck somewhere, you can then see the solution and learn what you were missing to get the solution on your own.

When solving the problem below follow these steps:

- **Draw a picture with all the forces acting on the rocket shown.**
- **Use Newton's 2nd Law to find its acceleration. DO NOT SUBSTITUTE NUMBERS! Try to get a general formula for acceleration *a* in terms of *F, M*, and *g*.**
- **Now substitute appropriate numbers in your formula and get result for both (a) and (b)**

Problem 2

The Apollo mission to Moon was lunched by a very powerful rocket called Saturn V. The total mass of the rocket right before launch was $M=2.8\times10^6$ kg. Total thrust (propulsion force) of 5 engines of the first stage is $F=34\times10^6$ 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 $m=2.1\times10^6$ kg. The force will remain constant at this point.