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."

$$\vec{F} = 0 \implies \vec{v} = const$$

Newton's 2nd Law:

"Force equals mass times acceleration"

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

Newton's 3rd Law:

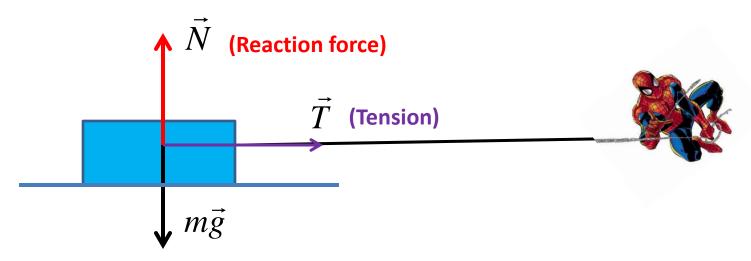
"Any Force of action has an equal and opposite Force of reaction" $\vec{F}_{B \to A} = -\vec{F}_{A \to B}$

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

Unit of force is called Newton (N)

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

Examples of Forces



(Gravitational force. g=9.8 m/s² is gravitational acceleration)

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

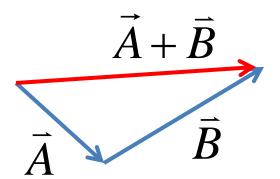
$$\vec{F}_{total} = \vec{N} + \vec{T} + m\vec{g}$$

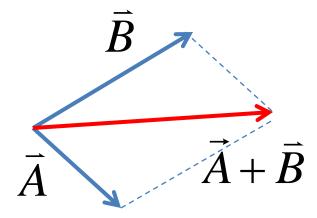
Adding vectors

There are two ways of thinking about **vectors**:

- **Geometrically,** vector is a directed line segment. It has direction and magnitude.
- **Algebraically,** vectors can be written as a list of numbers: their X, Y and Z components. For instance (3,4,-5).

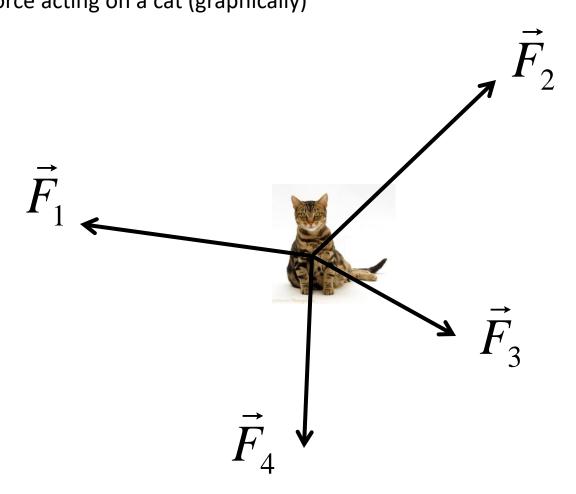
To add vectors A and B geometrically. you can use "triangle" or "parallelogram "rules:





Homework 9

Problem 1. Find the total force acting on a cat (graphically)



When solving the problem below follow these steps:

- Make picture with all forces acting on a rocket shown.
- Use 2nd Newton's Law to find 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

