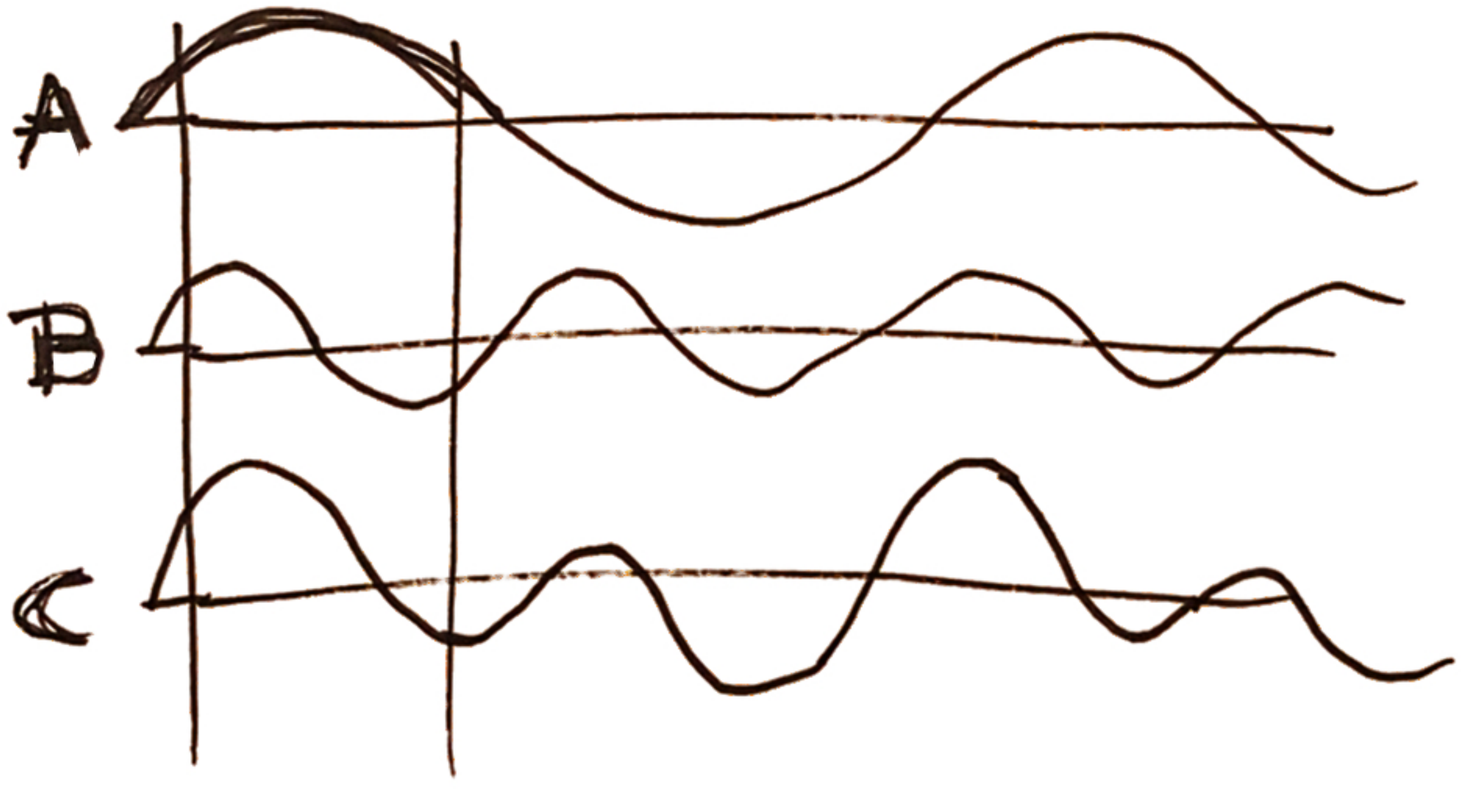
Superposition of waves (overlapping principle)

If two or more waves of the same nature (electromagnetic/sound) that propagate in the same medium overlap at a certain point in space → when the disturbance generated is equal to the algebraic sum of the oscillations of each wave taken individually.

Whatever the number of sound sources present, only one sound wave reaches our ears, possibly resulting from the sound waves produced by the various sources.

Instant by instant the instantaneous values of the amplitude of the different waves add up algebraically, that is, with their sign, positive or negative.



Waves in phase:

Two or more waves with the same frequency reach the maximum width in the same instant.

Phase opposition:

Two or more waves with the same frequency respectively reach the maximum amplitude in the same instant.
They have a phase difference of 180°.

Periodic wave - Mathematical function

$\exists\, T > 0 : \forall t \in \mathbb{R} \qquad f(t) = f(t+T)$

Esempio: $\sin(x) = \sin(x+T)$ and $T = 2\pi$

Frequency: Indicates the number of complete oscillations per unit of time. It's measured in Hertz [Hz] [1/s].

Period: It indicates the time it takes to complete a complete oscillation (circle to say it simpel...). It's measured in seconds [s].

$$T = \frac{1}{f}$$

(T: period; f: frequency)

Amplitude
Ampiezza: Used to discribe the maximum oscillation rank. The unit of measurement depends on physical magnitude disrupted.

* **phase**: Represents a generic part of the elapsed period with respect of a fixed time. It may have other meanings that depend on the specific type of wave.

* **initial phase**: represents the elapsed period with respect to the time instant 0.

* **pulsation**: Complete oscillation number in a time equal to 2π. Typically measured in radians per second [rad/s]. If f is the frequency (and T is the period), the pulse ω is valid:

$$\omega = 2\pi f = \frac{2\pi}{f}$$

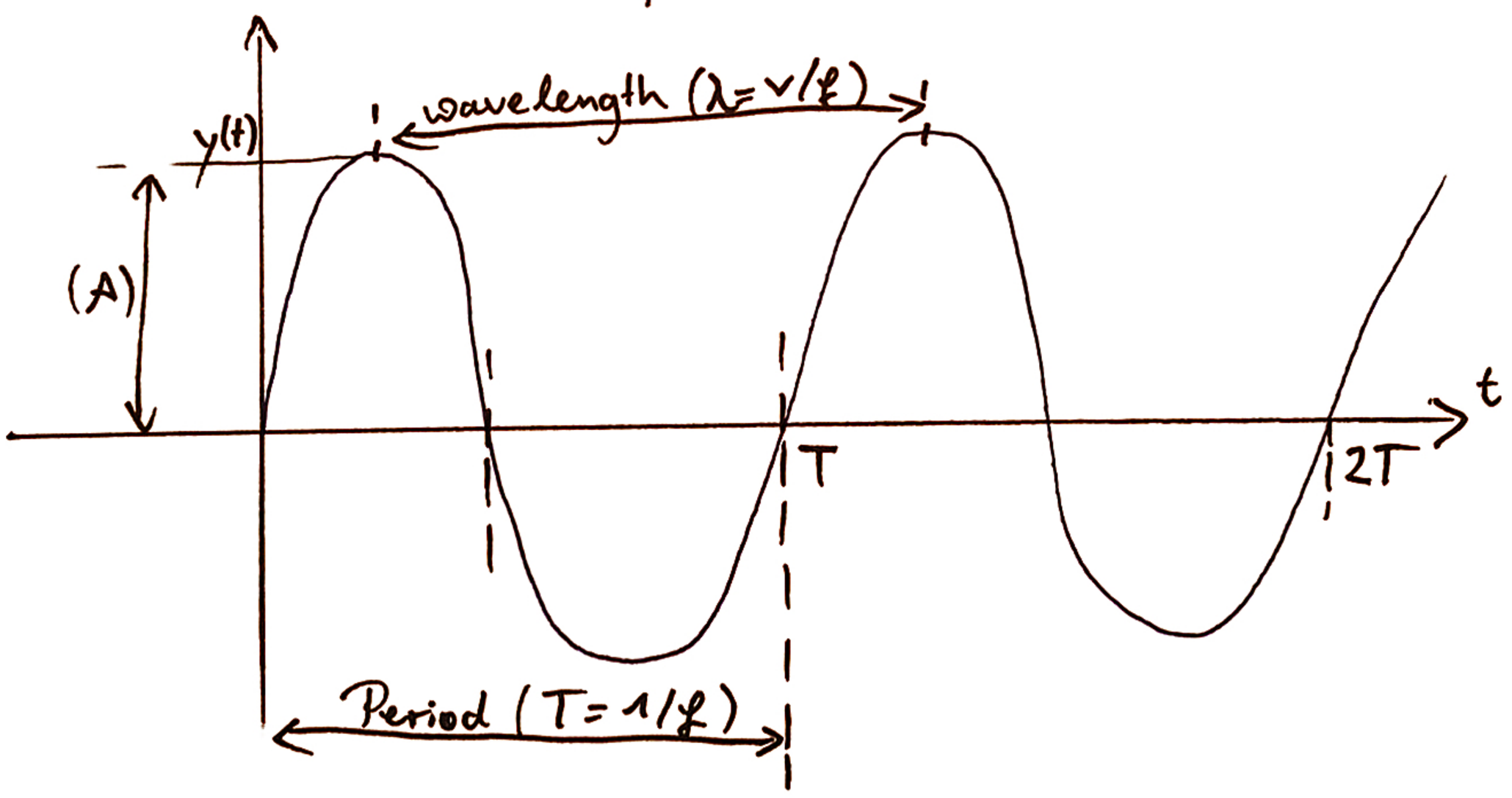
wave speed: Space covered by the perturbation (Störung) in time. Measured in meters per second [m/s]. It depends on the medium in which the wave is progressing.

wavelength: Distance traveled from the wave in the time necessary to pass from a maximum or minimum pedk to the corresponding maximum or minimum point of the subsequent oscillation → crests & bellies...

$$\lambda = v\,T = \frac{v}{f}$$

↑ speed

Measured in meters



example: $y(t) = 10 \sin(4\pi t + 4)$

- 10 → Amplitude
- 4π → Frequency
- 4 → Phase

Amplitude of sounds

A high amplitude corresponds to a high volume_ inverse the sound will be weaker.

The amplitude or intensity is the physical parameter that discribes the energy content carried by wave. In case of sound waves this energy is directly related to the local pressure variation.

Sound Pressure Level (SPL)

compared to particle pressure/ rarefaction

- air pressure variation
- silence corresponds to atmospheric pressure

variations are around 1/1.000.000 of the atmospheric pressure at sea level

↳ microphones and our eardrum can detect

Sound Intensity Level (SIL)

compared to the energy (intensity) transported by wave

$$\text{pressure} = \frac{\text{force}}{\text{surface}}$$

Example: • Woman: 50kg (≈500N)
• Area del tacco: $2cm^2$
• pressure $500/0,0002 =$
$2.500.000\ N/m^2$