Damping is a term for describing the losses of an oscillatory system (see Fig. 1 and left panel of Fig. 2). The losses can be internal, molecular friction (dissipation, causing generation of heat) and/or transmission to the surrounding elements, e.g., through the bridge and body of a string instrument to sound waves in the surrounding air.

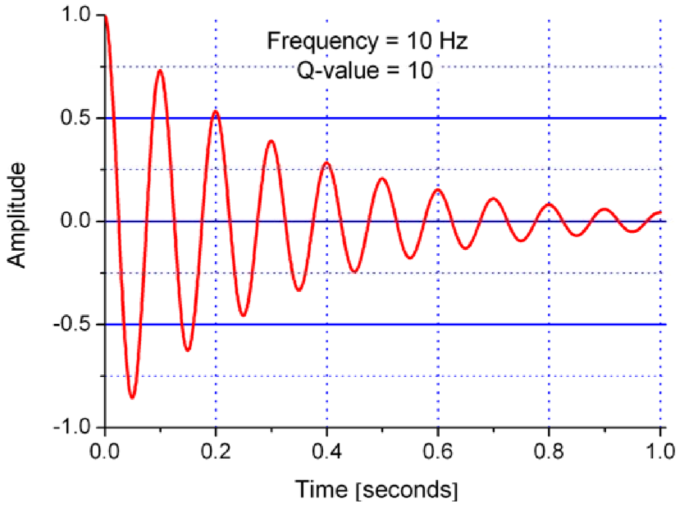

Figure 1: Example of amplitude reduction due to losses (damping). Here, the frequency is 10 Hz, and the Q-value 10, which implies that the amplitude has fallen to about 4.3 % of the initial amplitude after one second.

There are, however, a number of expressions for damping, all with a particular mathematical meaning. (Unfortunately, with words sounding so much alike, we can see some inconsistency also within the scientific society.) In the following these expressions will be defined as functions of Q-value (see entry "Q-value"), and T_{60}, where the latter is a measure of how long it takes (in seconds) to reduce the oscillation with 60 dB (i.e., to one millionth of the energy—barely audible, if at all).

Loss factor (commonly used symbol: η, dimensionless) is the inverse of the Q-value:

$\eta = 1/Q \approx 2.2 / (T_{60} f_0)$, where f_0 is the oscillatory frequency.

Decay ratio (not to confuse with radiometric dating), (commonly used symbol: D, dimensionless) is equal to half the value of η:

$D = 1/(2Q) \approx 1.1 / (T_{60} f_0)$.

Decay constant (commonly used symbol: σ, with dimension: "per second", $[s^{-1}]$):

$\sigma = \pi f_0/Q \approx 6.9/ T_{60}$.

Logarithmic decrement (commonly used symbol: Λ, dimensionless):

$\Lambda = \pi /Q \approx 6.9/(T_{60} f_0)$.

Damping coefficient is here the viscous damping coefficient, i.e., "mechanical resistance", realizable as a "dashpot", (commonly used symbol: c, with dimension [kg/s] = [N s/m]):

$c = 2 \pi f_0 \, mass/Q \approx 13.8 \, mass/ T_{60}$.

When the terminology of these expressions is so easily confusable, one might ask why there are so many terms. The answer is that one can significantly simplify equations by choosing the most suitable one, and when entered into equations, the context usually defines them clearly.

There are, however, three more expressions you should be aware of: **Overdamping**, **Critical damping**, and **Underdamping** (see Fig. 2).

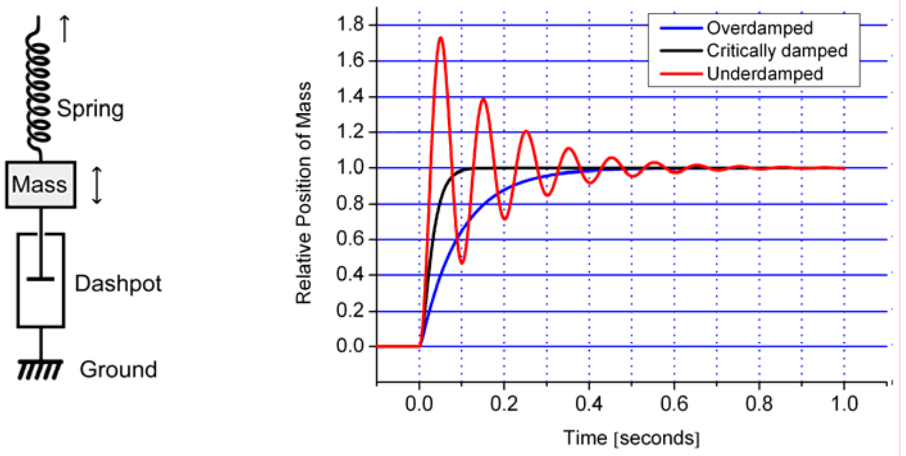

Figure 2: Examples of different degrees of damping: Overdamped, Critically damped, and Underdamped (see text).

When something resonates, the three elements shown at the left side of Fig. 2 will be present in one form or another. We can imagine that the mass is at rest first—in equilibrium with the attached spring. Then, at time = 0, the upper end of the spring is instantly brought to a higher level, being stretched, which will cause the mass to follow. Dependent on the level of damping (viscous resistance) provided by the dashpot, the position of the mass might now describe a damped sine wave, overshooting the new equilibrium level at first, before gradually settling at its new equilibrium level (see red line in the right panel of Fig.2). This is called *underdamping*, and is present in all instruments with soundboards and vibrating walls. (Without the dissipating dashpot effect, the sine wave would go on forever, *undamped*.)

At a certain higher level of damping, the mass will *not* overshoot, but find its approximate new position within a little more than one nominal period of the underdamped or undamped oscillation frequency (which is primarily dependent on the spring-mass ratio). This, being the quickest way of getting from level 0 to level 1 without overshooting, is called *critically damped* (see black line of Fig 2).

If the dashpot resistance is increased even further, the system is getting *overdamped*, and the transition will take longer than "necessary" (see blue line of Fig. 2). In elevators, the damping is usually overdamped to avoid "ringing" (the effect of oscillation after the chosen level is reached) and to give a soft landing at your destination.