

Q-value or **Q-factor** (“quality factor”, dimensionless) was originally a term for describing the quality of tuned electrical circuits, indicating the ability of the system to produce a large output at the resonance frequency. The less damping the system has at this particular frequency (often referred to as f_0 ; or ω_0 for the angular frequency), the sharper the peak appears in the spectrum.

The Q-value is defined as

$$Q = \frac{\pi}{\ln(a_0/a_1)},$$

where a_0 and a_1 are amplitude values of two consecutive periods, and $\ln(a_0/a_1)$ is the natural logarithm of their ratio.

There are several ways to calculate the Q-value. One commonly used method for estimating it from the spectrum is to measure the bandwidth between the two frequencies f_1 and f_2 , where the amplitude has fallen to the half power value (−3dB) with respect to the center (resonance) frequency, f_0 , between them. The Q-value can then be calculated as

$$Q = \frac{f_0}{f_2 - f_1}.$$

See Fig. 1 below:

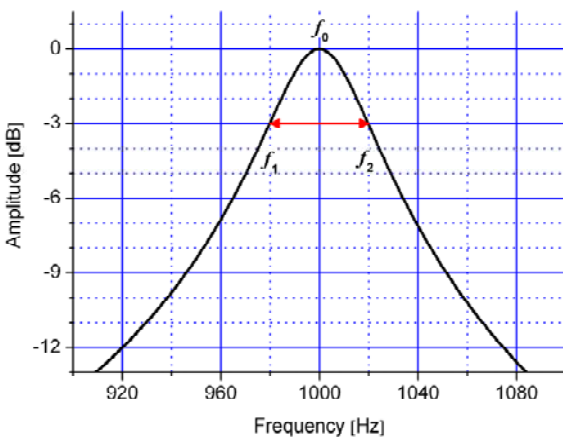


Figure 1: Calculation of Q-value based on the half-power bandwidth ($f_2 - f_1$). The centre frequency (f_0) divided by the half-power bandwidth (see red line) gives in this case a Q-value of 25.

The Q-value indicates how fast a resonance will fade out after the system excitation has ceased. If we define T_{60} as the time in seconds required for fading out 60 dB, we can approximate this duration by setting

$$T_{60} \approx \frac{2.2 Q}{f_0}.$$

In Fig. 1, where the Q-value is $1000 \text{ Hz} / 40 \text{ Hz} = 25$, the decay time T_{60} is approximately 0.055 seconds, or 55 milliseconds.

Strings (for bowing) have in general quite high Q-values when mounted in a rigid rig, not losing energy at its end points. Fig. 2 below shows some typical values of violin strings (source Fan Tao, head of research and development with J. D'Addario & Co Strings).

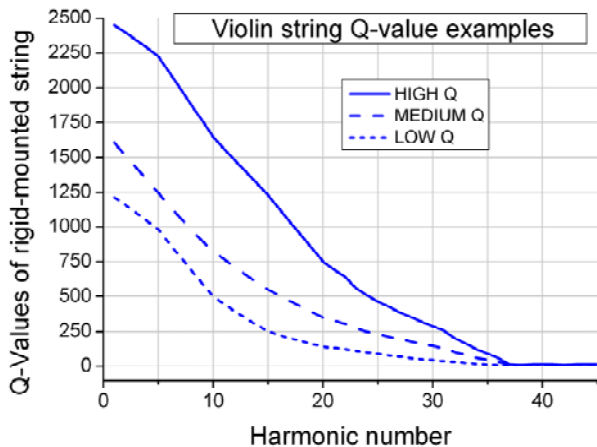


Figure 2: Typical Q-values of violin strings. The string with highest Q-values is the one most difficult to play, but giving the greatest brilliance, opposite to the string with the lowest Q-values.

When mounted on a violin, the total Q-values will drop considerably, with maxima of about 800.

Strings for pizzicato (jazz-bass strings with great sustain) will in general have higher Q-values than strings for arco, and are therefore more difficult to bow, because of the lower damping. During onset transients, damping is crucial for reducing impulsive peaks in the friction force, peaks that might cause premature slips during the nominal stick periods.