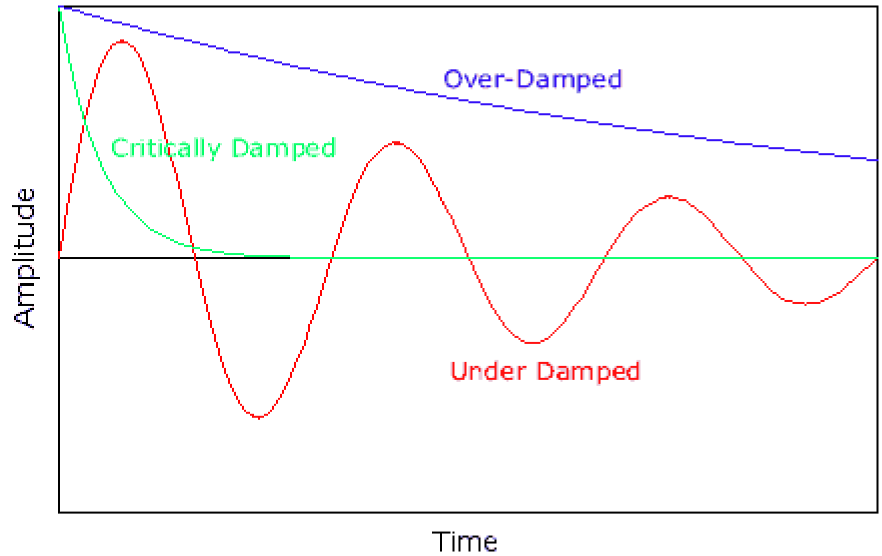
The following figure shows the effect of under-, critical and over-damping on the motion of a 1-D harmonic oscillator system:




Note that damping processes that are operative in ***all*** musical instruments are in the ***under-damped*** regime (since by definition, to be musical, they ***must*** vibrate at frequencies > 0), typically with small amounts of damping, *i.e.* $\gamma \ll \omega$, such that: $\boxed{0 < \omega' = \sqrt{\omega^2 - \gamma^2} = \omega\sqrt{1-(\gamma/\omega)^2} \lesssim \omega}$.

A more realistic motion of a vibrating mass on spring is that associated with *e.g.* driving it with a periodic force (corresponding to a linear, ***inhomogeneous*** 2nd-order differential equation):

- Have to get the mass moving first (initially at rest), takes a while for oscillations to build up
- Takes a finite time to reach a steady state displacement amplitude $x_o$
- When switch off the driving force, displacement amplitude decays away, as shown below:

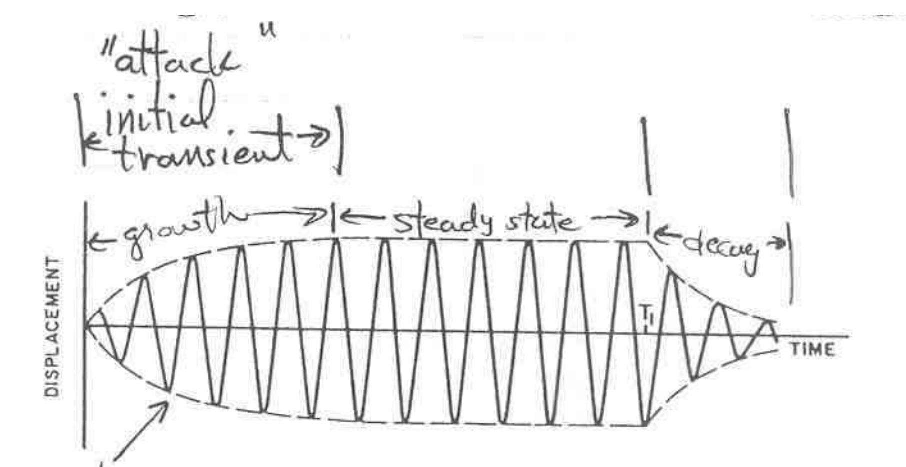



FIG. 4. Growth and decay of a vibration.

Slow attack – *e.g.* flute-like sound. Fast attack – *e.g.* more like trumpet/sax/*etc*.… type sounds
Slow decay → large sustain (*e.g.* solid-body electric guitar). Fast decay → little sustain (*e.g.* acoustic and/or hollow-body, archtop-type jazz guitar). Fast *vs*. slow attack & decay times are important aspects/attributes of the overall sound(s) produced by musical instruments!