Q-factor essentials sheet

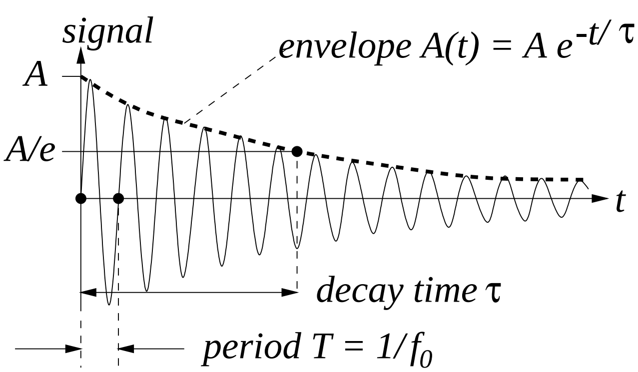
Q-factor is a measure of ‘quality’ of a particular resonance. Each normal mode, ie mode of oscillation, of a system has two important things: its resonant frequency (sometimes called f_0), and its Q-factor.

Q is a way of saying many things all at once, all of which follow from each other:

> high Q = ‘high quality’ = rings for many cycles (long decay time) after being hit
> = very little damping = peak width of frequency response is narrow
> = peak width of frequency response is tall.

Now in more detail... There are 2 simple things you can do to a system: hit it once (shown on left side) or excite (drive) it at a given frequency and see how much it responds (shown on right side) ...

DECAY AFTER SINGLE HIT



Oscillation with exponential decay in time.
τ *= how long to die to 1/e, about 37%*

happens to be the definition (of "π times")

$Q = \pi$ *times how many cycles in a decay time*

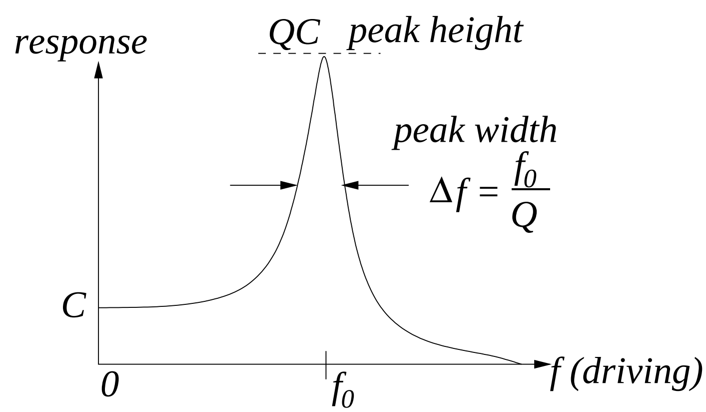
$= \pi\ (\tau / T)$

$= \pi f_0 \tau$

$= \omega_0 \tau / 2$

using $1/T = f = \omega / 2\pi$

RESPONSE TO DRIVING AT GIVEN FREQ



Low frequency response called C: all we’re saying is the peak height is Q times this.

The peak width is Q times narrower than the position of the peak in frequency.

Eg tuning fork has many thousands of cycles during decay time -> high Q, whereas a piece of jello (jelly) only wobbles a few times before settling down -> low Q. Therefore if you want to excite the jello you don’t have to get the driving frequency very accurate; with tuning fork you do.

It is amazing that all these properties are controlled through a single quantity, Q.