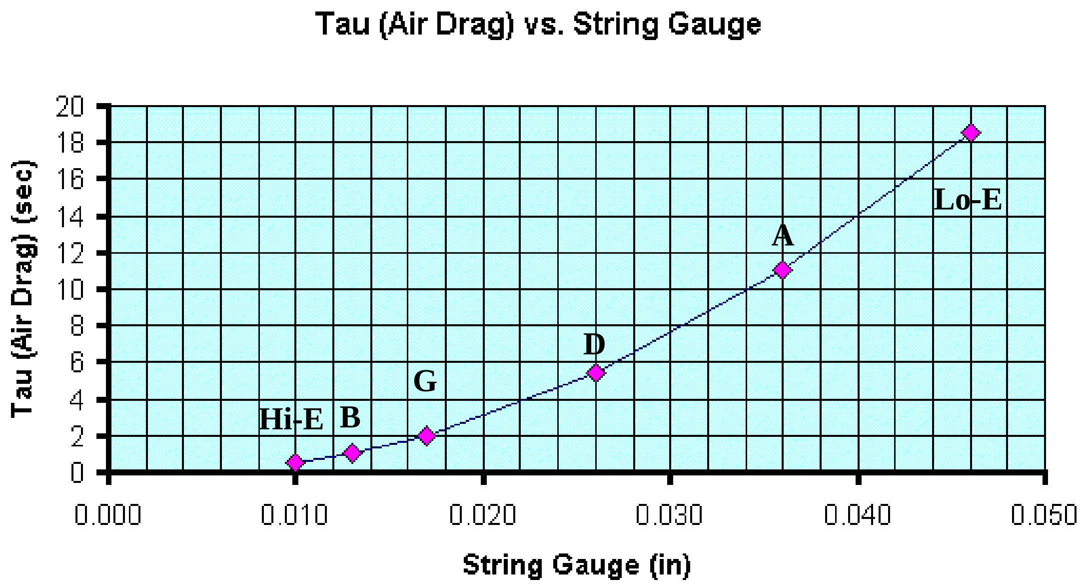
In the figure below, we show the calculated decay time constant associated with air damping/air drag effects on vibrating steel strings of the electric guitar vs. string gauge, using the above formula, for air at 1 atmosphere of pressure (i.e. sea level) and temperature, T = 20^o C.



The theory predicts a decay time in reasonable agreement with actual electric guitars for the low-frequency strings, but disagrees significantly for the higher frequency strings - the decay time here is *not* as short as the prediction would have you believe. Thus, for the smaller-gauge strings, the effect of viscous air damping is not as large as predicted!

Internal Damping Effects of Vibrating Strings

The material used in making e.g. electric guitar strings - steel, stainless steel for plain strings, and steel, stainless steel wrapped with pure nickel or a nickel alloy for the wound strings - behave as elastic materials. The strings of a guitar, of scale length, L_{scale} each have their own radius, r_{string} (m), (volume) mass density, ρ_{string} (kg/m^3). The ratio of stress (force per unit area, F/A) per unit strain (change in length per unit length, ΔL/L) in the material is known as Young's modulus, Y = (F/A)/(ΔL/L) (units: Newtons/m^2).

When a stress is applied to a material, an instantaneous strain occurs, but over a characteristic time scale, τ_{strain}, the strain increases slightly. Depending on the type of string material, this second strain can be moderately large or extremely small - the associated time scale, τ_{strain} can range from less than a millisecond to many seconds.

This relaxation behavior in strings can be represented mathematically by making Young's modulus, Y complex - i.e. an in-phase, or real component, Y_1 and a 90^o out-of-phase, or imaginary component, Y_2, relative to the phase of a vibrating string. Then $Y = Y_1 + iY_2$, where $i \equiv \sqrt{-1}$, and $i \times i = -1$, $i \times -i = +1$. From the relaxation theory worked out by the Dutch physicist Peter Debye, the value of the out-of-phase/imaginary component of Young's modulus, Y_2 has a peak at the relaxation frequency $f_{strain} = 1/\tau_{strain}$. However, in a real material, there may in fact be several such relaxation times, associated with normal elastic bond distortions between atoms making up the material, as well as relaxation times associated with motion of dislocations in the