Sound *Intensity* Level:

The human ear responds ~ *logarithmically* to sound intensity:

Loudness = Sound *Intensity* Level, L_I = SIL:
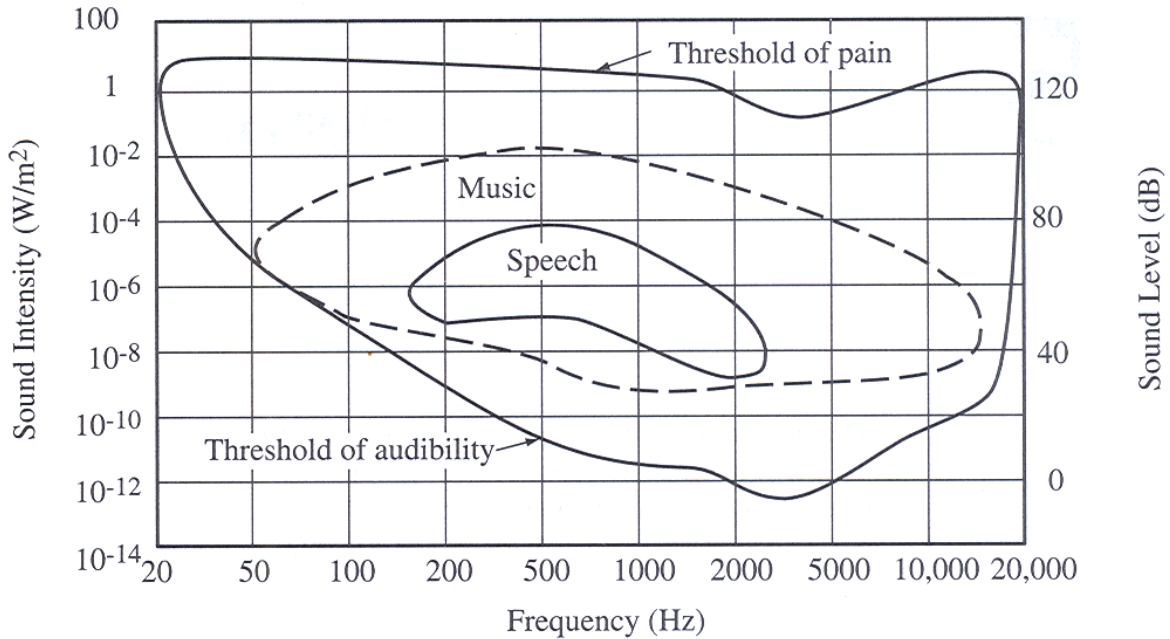$$SIL = L_I \equiv 10 \; \log_{10}\left(\frac{I_{rms}}{I_{o\,rms}}\right) \; (dB)$$

The unit of Loudness/Sound Intensity Level is the deci-Bel (*dB*) {*n.b.* deci = 10, *Bel* in honor of Alexander Graham Bell}.

Note that musicians have quantitatively defined <u>*six*</u> different loudness levels:

fortissimo	*fff*	$I = 10^{-2}$ RMS W/m^2	L_I (*dB*) = 100
	ff	10^{-3}	90
	f	10^{-4}	80
	p	10^{-6}	60
	pp	10^{-7}	50
pianissimo	*ppp*	10^{-8}	40

The Range of Human Hearing: Sound Intensity, Sound Intensity Level *vs*. Frequency:

Sound *Pressure* Level: SPL = L_p = Sound Pressure Level (units = deci-Bels, *dB*)

$$SPL = L_p \equiv 10\log_{10}\left(\frac{p_{rms}^2}{p_{o\,rms}^2}\right) = 10\log_{10}\left(\frac{p_{rms}}{p_{o\,rms}}\right)^2 = 20\log_{10}\left(\frac{p_{rms}}{p_{o\,rms}}\right) \; (dB)$$