The Difference Between Two *Uncorrelated* Loudnesses/Sound Intensity Levels:

Using the fact that: $\boxed{\log_{10} A - \log_{10} B = \log_{10}(A/B)}$

$\triangle L = L_2 - L_1$ = Difference in two Loudnesses (= Difference in two Sound Intensity *Levels*).

where:

$$L_1 = 10\log_{10}(I_1/I_o) \text{ and } L_2 = 10\log_{10}(I_2/I_o), \text{ then:}$$

$$\triangle L = L_2 - L_1 = 10\log_{10}(I_2/I_o) - 10\log_{10}(I_1/I_o)$$

$$= 10\left[\log_{10}(I_2/I_o) - \log_{10}(I_1/I_o)\right]$$

$$= 10\left[\left(\log_{10} I_2 - \cancel{\log_{10} I_o}\right) - \left(\log_{10} I_1 - \cancel{\log_{10} I_o}\right)\right]$$

$$= 10\left[\log_{10} I_2 - \log_{10} I_1\right] = 10\log_{10}(I_2/I_1)$$

If *e.g.* $I_2 = 2I_1$ then: $\triangle L = L_2 - L_1 = 10\log_{10}(2) = 10 * 0.301 = 3.01 \simeq 3\,dB$

i.e. there is only a $\approx 3\,dB$ difference in loudness/intensity levels for 2 (uncorrelated) sounds which differ by a factor of 2× in intensity, $I_2 = 2I_1$.

Adding *Uncorrelated* Sounds:

Two uncorrelated sounds with intensity levels L_1 and L_2 (*e.g.* at the same frequency)

$L_1 = 70\ dB$ and $L_2 = 80\ dB$ (@ $f = 1000$ Hz). Note that $L_2 = 80\ dB$ corresponds to $I_2 = 10\ I_1$:

$$L_1 = 70 = 10\log_{10}(I_1/I_o) \qquad L_2 = 80 = 10\log_{10}(I_2/I_o)$$

$$7 = \log_{10}(I_1/I_o) \qquad 8 = \log_{10}(I_2/I_o)$$

$$10^7 = (I_1/I_o) \qquad 10^8 = (I_2/I_o)$$

$$I_1 = 10^7 I_o = 10^7 * 10^{-12} \qquad I_2 = 10^8 I_o = 10^8 * 10^{-12}$$

$$= 10^{-5}\,W/m^2 \qquad = 10^{-4}\ W/m^2$$

Thus: $I_2 = 10I_1$ or: $I_1 = 0.1I_2$

Rule: Must add Intensities, NOT Loudnesses if sounds are *not* correlated
– *i.e.* if sounds have no *phase coherence*

Then: $I_{sum} = I_{TOTAL} = I_1 + I_2$ {If sounds *are* correlated, then *must* add
$= I_1 + 10\ I_1 = 11\ I_1$ *amplitudes* via phasor diagram → interference effect(s)!!!}

Thus: $L_{sum} = 10\ \log_{10}(11I_1/I_o) = 10\ \log_{10}(I_1/I_o) + 10\ \log_{10}(11) = 70\ dB + 10.4\ dB$

$= 80.4\ dB \Rightarrow$ only slightly louder than 80 *dB* !!!