NOTES ON LOUDNESS AND DECIBELS

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One of my physics professors correctly taught that if one airplane was flying overhead then ten airplanes would be required for the sound to be twice as loud.

Loudness is a human perception. An increase in the sound pressure level (SPL) of 10 dB is approximately perceived as being twice as loud. Note that decibel scale is logarithmic. The formula is given on the following page.

Furthermore, note that as sources are added that the resulting root-mean-square sound pressure increases as the "square-root-of-the-sum-of-the-squares."

Now consider an example where one airplane is flying overhead at a subsonic speed. The altitude, speed, engine type and other variables are such that the SPL level near the ground is 70 dB.

Now consider that the first airplane is joined by a similar one. Assume that the two aircraft are flying in formation so that no collision occurs. Assume that the resulting sound is steady-steady state for simplicity. The effect of the second airplane is to increase the SPL by 3 dB.

Similar airplanes are added one-by-one until there are ten airplanes overhead. The table below shows the progressive increase in the overall SPL. A diminishing returns effect occurs. The SPL level increases by a cumulative total of 10 dB when the tenth airplane is added.

Number	√ Number	Pressure (psi rms)	Overall SPL (dB)
1	1.00	9.20E-06	70.0
2	1.41	1.30E-05	73.0
3	1.73	1.59E-05	74.8
4	2.00	1.84E-05	76.0
5	2.24	2.06E-05	77.0
6	2.45	2.25E-05	77.8
7	2.65	2.43E-05	78.5
8	2.83	2.60E-05	79.1
9	3.00	2.76E-05	79.6
10	3.16	2.91E-05	80.0

The SPL in units of dB is calculated as

$$SPL = 20 \log \frac{P_{rms}}{P_{ref}}$$

where

P_{rms} is the measured root-mean-square sound pressure

P_{ref} is the reference sound pressure

The reference pressure for air is 20 micro Pa. This is approximately 2.9e-09 psi.