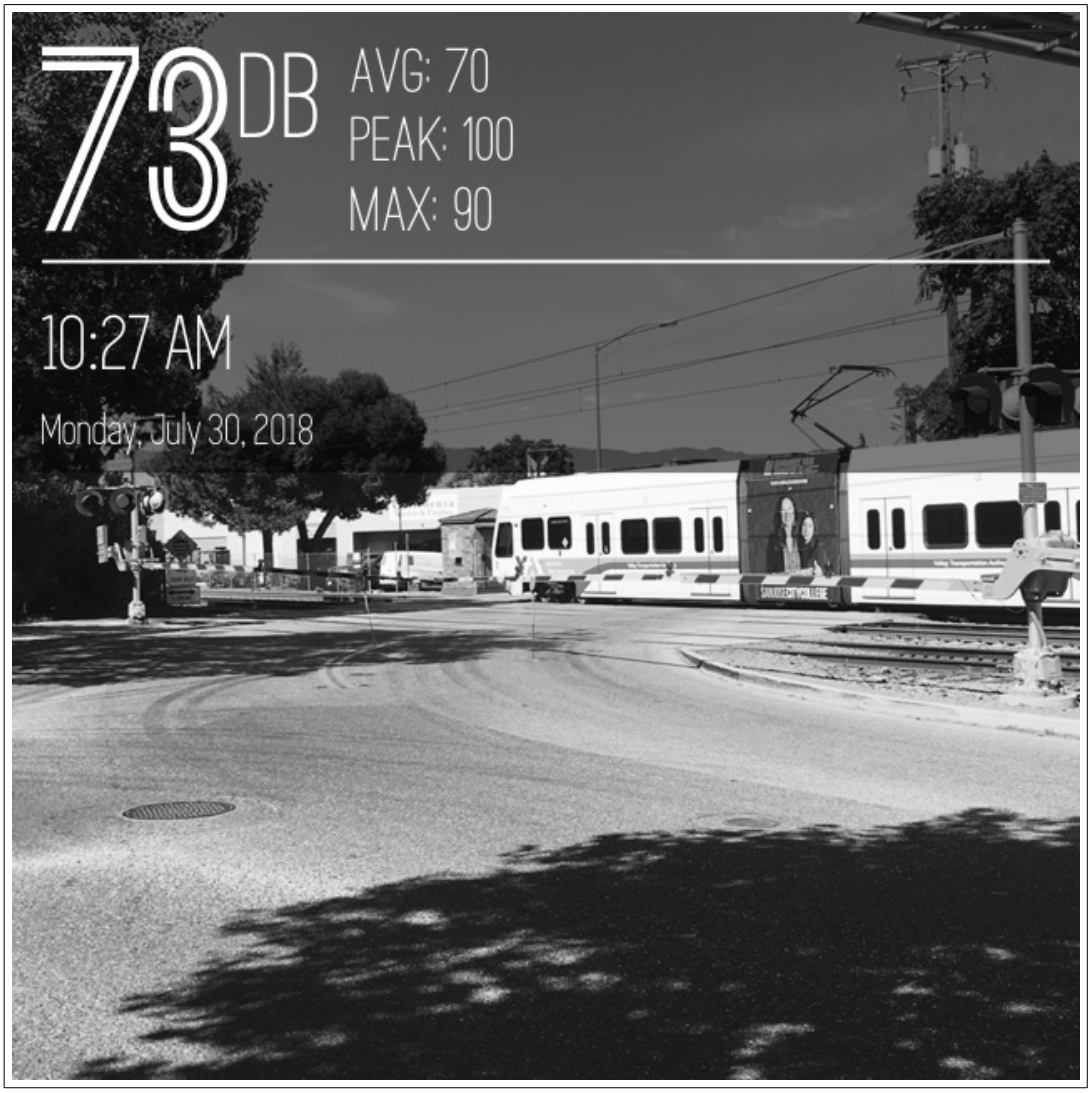
How Loud is 73 dB?



Light Rail in Campbell

Bruce Sawhill was over the hill in Campbell on Monday morning, and spent a few minutes at the intersection of Kennedy Avenue and the VTA Light Rail Line. With an app on his iPhone (see http://skypaw.com/decibel10.html), he measured how loud the Light Rail was as it went by at full speed. At about 50 feet from the train, it registered 73 dB. (The 100 dB "peak" happened when a large delivery truck passed next to him when it was going through the intersection.) Background city noise is about 56 to 62 dB when no vehicles of any sort are nearby.

Bruce told me that a sign on the pole at the left of the image—unreadable in this photo—says "No Train Horn".

What follows are a few notes that may help us answer the question posed in the title of this note.

1. **About Decibels (sound levels):**
   Decibels are precisely defined by the formula $\beta = 10\log(I_2/I_1)$, where I_2 is the **intensity** of one sound wave, and I_1 is the **intensity** of another sound wave. The (dimensionless) units

of β are **dB** or **decibels**. Thus if one sound wave is twice as intense as another, the sound level of the first is greater than that of the second by $10\log(2) \approx 3\,\text{dB}$. Typical units for **intensity** are watts per square meter.

Since the **intensity** of a wave is proportional to the square of its **amplitude** (how far back and forth a molecule moves in a wave), one having twice the amplitude of another will have a greater sound level of $10\log(2^2) = 10\log(4) \approx 6\,\text{dB}$.

One often sees a statement that some single sound level is some number of decibels, for example, 70 dB. This kind of statement implies that I_1 (the reference level) is taken to be equal to 10^{-12} watts per square meter, which is the currently accepted minimum **intensity** that a healthy human can detect. Thus a sound wave said to have a sound level of 70 dB has an **intensity** of $I_2 = I_1 \times 10^7 = 10^{-12} \times 10^7 = 10^{-5}$ watts per square meter.

2. **About Loudness:**
The measure of the **loudness** of a sound wave, or of the noise created by some piece of machinery, like a printing press or a train, or existing in some environment, like a quiet wilderness or an urban street, is *not* as precisely defined as are the physical measures of **intensity** or **amplitude**. This is because the concept of **loudness** involves what humans perceive, and so involves a psychological factor. One asks a human (or many humans) "Please tell me when some sound is made to be, say, 'twice as loud' as I increase the volume, or 'half as loud' as I decrease the volume."

   It is now generally accepted (presumably based on experiment), that an increase of 10 dB is perceived as "twice as loud", and that a decrease of 10 dB is perceived as "half as loud".

3. **Tables of Comparisons:**
On the internet one finds tables that list sound levels for various noise sources. See, for example: http://www.industrialnoisecontrol.com/comparative-noise-examples.htm. Such tables are useful for being able to answer our question: **"How loud is 73 dB?"**

   The table referenced in the above link says that "70 dB is the arbitrary base of comparison", and that "sound levels in the upper 70s are annoyingly loud to some people". It states that "a passenger car at 65 mph at 25 feet is 77 dB", that "living room music is 76 dB", and that "radio or TV-audio is 70 dB".

   This table also says that "100 feet from a diesel train at 45 mph produces 83 dB", which is more than twice as loud as our VTA light rail. (This diesel train at **50 feet** would register at 86 dB.) **Light rail trains are remarkably quiet.**

– Peter Scott