Orchestral Sound Activity

You can hear plenty of sound in a concert hall where an orchestra is playing. Each instrument vibrates in its own particular way, producing the unique sound associated with it. The acoustical power coming from these instruments originates with the musician. It is the energy of a finger thumping on a piano key and the energy of the puff of air across the reed of the clarinet and the energy of the slam of cymbals against each other that causes the instrument’s vibration. Most people are surprised to learn that only about 1% of the power put into the instrument by the musician actually leads to the sound wave coming from the instrument. But, as you know, the ear is a phenomenally sensitive receptor of acoustical power and needs very little power to be stimulated to perception. Indeed, the entire orchestra playing at once would be loud to the ear, but actually generate less power than a 75-watt light bulb! An orchestra with 75 performers has an acoustic power of about **67 watts**. To determine the sound intensity level at 10 m, we could start by finding the sound intensity at 10 m:

The sound intensity level would then be:

The follow table lists the sound intensity level of various instruments in an orchestra as heard from 10 m away. You can use these decibel levels to answer the questions throughout this activity.

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| Orchestral Instrument | Sound Intensity Level at 10 m (dB) |
| Violin (at its quietest) | 34.8 |
| Clarinet | 76.0 |
| Trumpet | 83.9 |
| Pair of Cymbals | 98.8 |
| Bass Drum (at its loudest) | 103 |

1. How many clarinets would it take to equal the acoustic power of a pair of cymbals? (**190.5**)
2. If you had to replace the total acoustic power of a bass drum with a single light bulb, what wattage would you choose? (**25 W**)
3. How far would you have to be from the violin (when it’s at its quietest) in order to barely detect its sound? (**550 m**)
4. If the sound emerges from the trumpet at 0.5 m from the trumpet player’s ear, how many decibels does he experience during his trumpet solo? (**109.9 dB**)
5. If the orchestra conductor wanted to produce the same overall sound intensity, but only use violins (when at their quietest) to produce the sound, how many would need to be used? How about if it were to be done with bass drums (at their loudest)? (**17.7 million, 2.68**)
6. The conductor has become concerned about the high decibel level and wants to make sure he doesn’t experience more than 100 *dB*. How far away from the orchestra must he stand?(**23.02 m**)
7. If he doesn’t use the bass drum in the orchestra, how far away does he need to stand? (**18.3 m**)