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P5_6 Living on a Prayer

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Abstract

The big hit "livin' on a prayer" by Bon Jovi is still a popular song to this day, but when it comes to the physics of "living on a prayer", what does it take? When interpreting this phrase, a prayer can be said by an individual person at a normal speaking volume of 60 dB. It was found that it would require 41,000 people to produce enough sound pressure to levitate a 70kg man we will call Dave. For the least amount of people, it was found that 37 people would have to scream at 121 dB to be able to levitate Dave. For both cases this is assuming no pressure loss over distance.

Introduction

Released in late 1986, Bon Jovi's hit single "livin' on a prayer" became world famous by topping the charts of the late 80's. In this paper we examine what it takes to really "live on a prayer". Is it possible, assuming the sound waves are converted 100% to pascals, to levitate someone with the same decibels that nuns would pray at, hence "living on a prayer". This paper assumes the person, lets call him Dave, being levitated has a mass of 70kg and is standing on a 1m² aluminium sheet, so as to be able to capture the most amount of force applied by the sound waves. This paper will also be examining what the most optimal balance is between amount of people creating sound waves and how loud they have to scream. The loudest scream ever made by a human was 121 dB [1] while the average sound level of human speaking (or praying) was found to be 60 dB [2].

Theory and Equations

As mentioned, the person being levitated is assumed to be 70kg, but standing on an aluminium

sheet (he'll have to hold on to what he's got!) that has a mass of 13.5kg [3] (the sheet dimensions are 1 m x 1 m x 5 mm). Hence, there is a total mass of 83.5 kg, which is 819.135 N, but this will be rounded up to 820 N for ease.

When looking at sound waves, most sounds waves in real life apply a small pressure and the rest is either reflected or transmitted through a material, but this paper assumes the whole sound wave is directly converted to pascals. The last assumption about sound waves is that they don't have a 1/r decay rate, instead whatever pressure is created initially is what the sound wave will have.

Using the equation (1) [4], where L is the number of decibels being produced, p is the sound pressure (in pascals) generated and p_0 is the reference sound pressure (which is always 0.00002 Pa, p_0 is a constant [4]). We're halfway there!

$$L = 20 \log(p/p_0) \quad (1)$$

Re-arranging equation (1) gives the option of inputting decibels to get out pressure, the variable that is needed for this paper.

$$p = 10^{L/20} p_0 \quad (2)$$

Assuming 1 person screams at 121 dB, using equation (2) this generates a pressure of 22.44 Pa, equivalent to 22.44 N m². Meaning 37 people would have to scream at 121 dB to be able to levitate Dave. Figure 1 has been created to show the relationship between the amount of people needed to generate sound waves and how loud they would have to scream. The figure gives an understanding of the optimal balance for the least amount of people screaming at the lowest volume (lowest decibels).

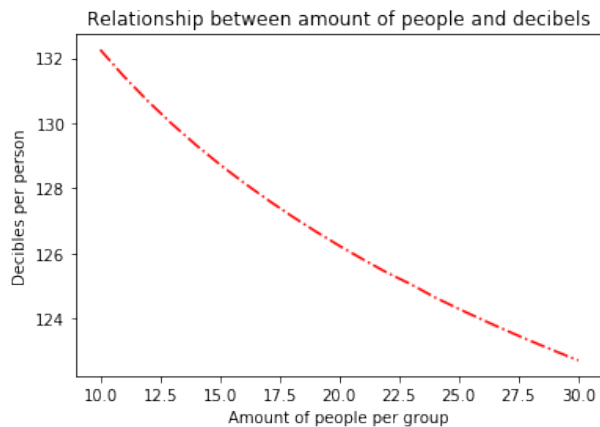


Figure 1: The graph above shows how loud each person in a group would have to scream to levitate Dave with x-axis being the amount of people in each group

However, although Figure 1 is useful, this paper is about "living on a prayer", as stated previously the average human voice speaks at 60 dB, hence using equation (2), it is found that a person "praying" at 60 dB would create a pressure of 0.02 N m², meaning it would take 41,000 people praying at 60 dB to create enough force levitate Dave. (They've got each other and thats a lot!)

Conclusion

After making assumptions in the favour of levitating Dave (no sound pressure loss and all sound waves solely converted to sound pressure), 41,000 are still needed to levitate a person

standing on a sheet of aluminium when speaking/praying at a level of 60 dB, however this number would greatly increase if sound pressure loss occurs as the further away from Dave they are, the less sound pressure is transferred into the sheet to balance the forces. However in real life, with all laws of physics applied, the more viable option would be having 37 people scream at 121 dB due to reduced spread of humans (thus less sound pressure loss).

Woooahhhh, livin' on a prayer!

References

- [1] <https://www.belfasttelegraph.co.uk/news/northern-ireland/worlds-loudest-shout-belongs-to-northern-ireland.html>
- [2] <https://www.alpinehearingprotection.co.uk/5-sound-levels-in-decibels/> [Accessed 1 November 2020]
- [3] <https://www.steelexpress.co.uk/steel-weight-calculator.html> [Accessed 1 November 2020]
- [4] <http://www.sengpielaudio.com/calculator-soundlevel.htm#:~:text=Important%20to%20notice%3A%201%20Pa,1%20bar%20%3D%20105%20Pa.>