Journal of Physics Special Topics
An undergraduate physics journal

A3_2 If a Tree Falls...

L. Flood, K. Holland, T. Leversha, M. Manley

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

December 15, 2022

Abstract

In this paper we are investigating the distance a person can be away from a tree to still be able to hear it fall. We have calculated that the furthest away a listener can be within an infinite forest, to still be able to hear a tree fall is approximately 285 m. We also calculate if a listener within a city would be able to hear the tree fall from the edge of an average forest.

Introduction

Everyone has heard the age old question "if a tree falls in a forest and no one is around to hear it, does it make a sound?". Whilst this question usually leads to numerous philosophical debates, we investigate if there is a mathematical approach that can be taken. To do this we calculate the distance away from a source a person, with no hearing defect and no sounds from the surrounding area, can stand to still be able to hear the tree fall.

Theory

In order to calculate the furthest distance a listener can stand, we must take into consideration sound attenuation and the affect woodland has on sound intensity. The equation we will use is for the sound attenuation over a distance[1]:

$$L_{p2} = L_{p1} - 20 \log \frac{R_2}{R_1} \tag{1}$$

Where R_2 is the distance from the source to the person, R_1 is the distance from the source to where the source sound intensity was measured, L_{p1} is the sound pressure at R_1 and L_{p2} is the sound pressure at R_2.

There is an average decrease of 7.5 dB every 30 m of woodland according to Forest Research[2], meaning approximately 0.25 dBm^{-1} is lost due to the trees in the forest. Therefore Eq.1 can become:

$$L_{p2} = L_{p1} - 20 \log \frac{R_2}{R_1} - \frac{(R_2 - R_1)}{4} \tag{2}$$

Where $(R_2 - R_1)/4$ takes into consideration the amount of sound propagation blocked by the other trees in the forest.

Results

The assumptions we made to use Eq.2 are that the sound intensity of a tree falling at source is the same as for a plane taking off, approximately 120 dB [3] and as this is the measurement for a close observer we assume that the recording of the sound pressure level was taken 1 m away from the source. We use the value of 120 dB for the tree falling due to an article saying that the sound of a tree falling was thought to be a train accident in nearby towns[4]. If the sound was described as being this loud hundreds of metres away from the fallen tree, then the sound pressure level 1 m away from the actual tree falling would be significantly larger.

The lowest sound pressure a human can hear is 0 dB[3]. As the rearrangement of Eq.2 for R_2 provides a difficult final equation, through trial and error calculations we find the maximum distance from within a forest the listener can stand, these are shown in Table 1. The results were found using 120 dB for L_{p1} and 1 m for R_1.

Table 1: Results from Equation 2

R_2 (m)	L_{p2} (dB)
500	-59
400	-32
300	-4.3
290	-1.5
285	-0.10
284	0.18

From this table, it is possible to see that the furthest the person can stand is around 285 m from the tree falling to still hear it.

Finally, we thought it would be interesting to calculate how loud the decibel level would be at the edge of an average forest and, therefore, if a passer by who lives in a city would be able to hear the tree fall when surrounded by traffic. We assume traffic is about 80 dB[3], the radius of the forest is 41 m and the tree falling is directly in the centre of the forest. We find the value for the radius of the forest by taking the mean of the two extremes of forest areas the UNFCCC uses for the definition of a forest[5] and found the radius of the value by assuming the forest was circular in shape.

Using the values 120 dB for L_{p1} and 1 m for R_1, but also this time using 41 m for the value of R_2 we find that the sound of a tree falling at the edge of our forest would be approximately 78 dB. Therefore the traffic being 80 dB means that a passerby would not be able to hear a tree fall from a forest of our size.

Conclusion

In conclusion, we have found that when standing in a forest of infinite size, a person is able to hear the sound of a tree falling from around 285 m away. However if the person was walking next to a 5250 m^2 forest within a city where the loudest surrounding sound was traffic, then they would not be able to hear the tree fall as the sound pressure level is about 2 dB levels lower than that of traffic. Whilst this might not answer the philosophical side of the question “if a tree falls in a forest and no one is around to hear it, does it make a sound?”, we have found a scientifically reasonable answer. To try and find a more accurate answer, noises within the forest could be considered as even a secluded forest will have other noises louder than 0 dB within it.

References

[1] `https://www.engineeringtoolbox.com/inverse-square-law-d_890.html` [Accessed 12 October 2022]

[2] `https://www.forestresearch.gov.uk/tools-and-resources/fthr/urban-regeneration-and-greenspace-partnership/greenspace-in-practice/benefits-of-greenspace/noise-abatement/` [Accessed 14 October 2022]

[3] `https://ec.europa.eu/health/scientific_committees/opinions_layman/en/hearing-loss-personal-music-player-mp3/figtableboxes/table-1.htm` [Accessed 12 October 2022]

[4] `https://education.nationalgeographic.org/resource/tall-trees` [Accessed 25 October 2022]

[5] `https://unfccc.int/files/land_use_and_climate_change/application/pdf/revegetation_colombia_presentation.pdf` [Accessed 25 October 2022]