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A4_9 Can Human Screams Power A Roller Coaster?

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Abstract

In this paper the energy collected from people screaming on the popular roller-coaster ride, Stealth, is explored using the sound intensity of their screams. This is then compared against the actual energy needed to power Stealth. It is found that the energy collected from the screams is 66.1 J and the energy needed to power the ride is 5.57 MJ, so unfortunately human screams would not be able to power the roller-coaster.

Introduction

Stealth is the fastest roller-coaster in the UK and the second tallest [1]. With people racing to fill queues, wait hours to brave this ride and experience the thrill and adrenaline from it, what if we could make some use out of all their screams? This paper aims to investigate how much energy we could collect from their screams and if we could use this energy to power Stealth.

Discussion

We begin by calculating the intensity of sound, I, produced by the screams of each person on the ride. We do this by rearranging the logarithmic equation in [2] to give Eq.(1),

$$I = I_0 10^{L_I/10}, \quad (1)$$

where $I_0 = 10^{-12}$ Wm^{-2} and is the sound intensity of the standard threshold of hearing for humans [2]. The sound intensity level is the logarithm of the ratio of a given intensity of sound, in a given direction, to the reference sound intensity [9]. L_I is the sound intensity level in decibels of the sound wave we are investigating (a human scream). The loudest a human can scream is 129 dB [3] so $L_I = 129$ dB. This gives us a sound intensity of I= 7.94 Wm^{-2}.

Before converting this sound intensity to the power the screams produce, we need to first think about how the screams will be collected and what the intensity of the screams will be at the collection point as intensity decreases with distance from the source. If we placed a storage device at the back of each chair and the storage device had a length and width of the same size as the average width of a chair, which is 0.508 m, [4] then the area of the storage device, A, would be 0.258 m^2. Now, using Eq.(2) [5], we can find the sound intensity the device receives, I_2,

$$\frac{I_2}{I_1} = \frac{r_2^2}{r_1^2}, \quad (2)$$

where, $I_1 = 7.94$ Wm^{-2}, and is the sound intensity of the scream at the mouth, $r_1 = 0.127$ m, and is the throat to mouth distance [6] and r_2 = 0.635 m (average length of a human arm) [7] and is the throat to device distance. The average length of a human arm was used as the throat to device distance as the shoulder is level with the throat, where the scream sound would start from, and for a comfortable seating experience there should be at least an arms length distance between a person and the seat in front of them. Rearranging for I_2 we calculate a value of $I_2 = 0.221$ Wm^{-2}.

Then, we need to convert this sound intensity to the power, P, the screams produced using Eq.(3),

$$P = I_2 A, \tag{3}$$

the power is calculated to be $P = 0.0570$ Js^{-1}. This is the amount of power produced by one scream. On each ride there are a maximum of two trains in operation, with 20 people seated in each train [1]. This means the power produced by 40 screams would be $P = 2.28$ Js^{-1}.

We can now calculate the energy produced by the screams, E, using Eq(4),

$$E = Pt, \tag{4}$$

Where $t = 29$s and is the duration of the ride [1]. Assuming each person will only scream once and can hold out their screams for this length of time, the energy produced by the screams will be 66.1 J.

Now, we need to determine whether this would be enough energy to power Stealth by calculating the total energy required to power Stealth. During a roller-coaster ride, the Gravitational Potential Energy (GPE) at the top of the hill gets converted to Kinetic Energy (KE) at the bottom. Some energy is lost to heat and sound but if we ignore these losses, we can determine the energy needed by calculating either KE or the GPE. We can calculate the KE, using the standard Kinetic Energy formula, where m is the mass of the train when filled with passengers. An empty car weighs 550 kg [8] and each person on average weighs 79.8kg, if there are two trains in operation, and each train has 5 cars [1], then two filled trains with 40 people, will have a mass, m = 8690 kg. The maximum velocity of each train is $v = 35.8$ ms^{-1} [1]. This gives a value of 5.57 MJ for the kinetic energy. Therefore, the total energy needed to power Stealth is 5.57 MJ.

Conclusion

The energy produced from people screaming during the ride Stealth, is calculated to be 66.1 J in comparison to the energy needed to power the roller-coaster, which we calculated as 5.57 MJ. This means that unfortunately we could not collect and use the energy generated by the screams to power the roller-coaster. Stealth would have to run almost 85,000 times for the energy collected to equal one ride on Stealth.

References

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