Journal of Physics Special Topics
An undergraduate physics journal

A3_10 Christmas Spirit

S. Shingles, D. Potts, E. Morton, M. Capoccia, R. Hodnett

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

December 16, 2019

Abstract

In this article we explore the amount of energy that can be produced from Christmas spirit. We investigated an event shown in the movie *'Elf'* where Santa Claus' sleigh needs the energy of Christmas spirit to raise it off the ground and back into the air. We found that to raise the sleigh required a total Christmas spirit of 4.51×10^{14} J. We find that each person shown in the film would need to produce 2.49×10^{12} J, yet if this Christmas spirit was shared amongst everyone in the world they would only need to produce 71.0 kJ.

Introduction

In the 2003 Christmas film *'Elf'*, Santa Claus crash lands in New York's Central Park and looses the engine to his sleigh. Santa states to Buddy the Elf that due to a shortage of Christmas spirit, without the engine the sleigh cannot fly. In an attempt to help Santa, various groups gather together and sing the Christmas song, *'Santa Claus Is Coming To Town'* to raise the Christmas spirit and help Santa fly his sleigh [1]. In this article we will investigate the amount of energy required to lift Santa's sleigh and thus the amount of energy a person can produce from jolly Christmas spirit.

Theory and Results

The crashed sleigh is travelling along the ground in Central Park before being raised up due to Christmas spirit. The energy required to raise the sleigh is shown by equation (1), where E is the energy, m is the mass of the body being raised, g is the gravitational acceleration due to the Earth and h is the height it is raised to.

$$E = mgh \tag{1}$$

We assumed that the height at which Santa's sleigh was raised is the same as that of a typical aircraft (≈ 11.5 km) [2]. We determined the mass of the sleigh by considering everything inside and attached to it. In the scene Santa and Buddy the Elf sit inside the sleigh with a huge bag of presents, all of which is being pulled by nine reindeer. The reindeer all have their antlers, an indication that these reindeer are female [3], that on average weigh 140 kg each [4]. Buddy the Elf, though his name suggests otherwise is in fact a human and we took him to weigh 70 kg. Santa is often depicted as a fairly plump man, often stated as a result of the large amounts of mince pies and cookies consumed during his stressful journey! As a result we shall assume Santa weighs a jolly 160 kg [5]. Finally the weight of the bag of presents for all the children across the world. We assumed that Santa gives every child in the world two presents, with each present weighing on average 1 kg (based on the average weight of some toys shown in [6]). In 2003, the number of children (0-14 years) in the world was roughly 2 billion [7]. Combining these

values we found that the total weight of the sack of presents to be 4×10^6 tonnes.

Summing all these components together we can calculate the total weight of the sleigh. We find that the total weight of the body being lifted is 4.00149×10^6 tonnes. Using this value in equation (1), we find that the energy required to lift Santa and his sleigh is 4.51×10^{14} J. In the scene we counted 181 people, all of which we assumed to be singing the Christmas song. Therefore, each person singing produces 2.49×10^{12} J of Christmas spirit. However it is likely that many more people were providing valuable Christmas spirit than that shown in the scene as it was broadcast on the news. In 2003, on Christmas Eve the world population was 6,354,138,584 [8], if all of these people were involved in helping Santa's sleigh fly then each person was producing 71.0 kJ of Christmas spirit.

Discussion

If the scene in *'Elf'* is to be believed with only 181 people involved in generating Christmas cheer then each person must produce a very large amount of energy through their Christmas spirit to raise Santa and his sleigh. These people are producing energy equivalent to 60% the energy produced from an explosion of a kiloton of TNT (4.184×10^{12} J) [9]. In fact, the average UK house hold uses 1.3×10^{10} J per year [10], meaning in this short moment of Christmas spirit, each person could power an average UK house for roughly 192 years. However, if the Christmas spirit was shared among everyone in the world then the energy requirement is significantly less. On average, 100 Christmas lights consume 144×10^3 J of energy per hour [11]. Therefore everyone in the world at this moment was producing enough energy to power Christmas lights for 30 minutes!

However, it is likely that our calculations are overestimates due to a few assumptions we made. Firstly in our calculation of the mass of the sack filled with presents. It is often regarded that Santa does not give presents to children who have been naughty in the year, however we have assumed that Santa was feeling especially generous that year and delivered presents to all children in the world. Secondly, not all the nations and peoples in the world celebrate Christmas. This therefore means that our estimate of the Christmas spirit shared among the world will be larger than its true value.

Conclusion

We have found that the energy that can be created from Christmas spirit and that needed to raise Santa and his sleigh is very high. We have found that if only the 181 people shown in 'Elf' are the ones generating this Christmas spirit then they must each produce 2.49×10^{12} J. However if this Christmas spirit is produced by the whole world then we find that every person must be producing 71 kJ to raise Santa back up into the air. It is clear to see that the energy that Christmas spirit possesses is significant and may be the source of Santa's magical capabilities, an area perhaps for further investigation.

References

[1] https://bit.ly/2E4QPca

[2] https://bit.ly/2YC00Kw

[3] https://bit.ly/34oyrq4

[4] https://bit.ly/36tRDU9

[5] https://bit.ly/2YBXfsJ

[6] https://bit.ly/34ddY6E

[7] https://bit.ly/34DJ88B

[8] https://bit.ly/2Do9i2S

[9] https://bit.ly/34aZxjy

[10] https://bit.ly/2DpyUwg

[11] https://bit.ly/2rxLbMs

All websites were accessed on 27 November 2019