

The Physics of Santa and His Reindeer

Every Christmas, calculations circulate that have been dubbed "The Physics of Santa Claus". The calculations cast doubt as to whether Santa Claus could possibly deliver gifts to all the world's good children – and still remain within the laws of physics. To deliver gifts to all who deserve them, they assert, Santa would need to move so fast that he would vaporize due to air resistance, be torn to pieces by gravitational forces or suffer other terrible fates we wouldn't wish for Santa Claus. Many fall for these calculations. Because, even though the physics of the calculations is apparently good, the reasoning rests on a completely wrong premise, namely that Santa Clause does not exist. Even small children understand that this premise is completely wrong! How will Santa Claus ensure that all the good children receive their presents and once again save Christmas?



World Households

According to the Population Reference Bureau, the world population in 2008 was approximately 6, 705 million; 28% of these are children (defined as being under 15). Thus, there are about 2 billion children in the world. Assuming that Santa caters to Christian children only and does not bother himself about children of other religions, he still has 33% of the above population of children to think about (according to the Encyclopedia Britannica's 2005 survey). 33% of 2 billion means over 600 million children, which is certainly an enormous workload, even for benevolent and kindly Santa. At an average (census) rate of 3.5 children per household, assuming that there is at least one good child in each, Santa has to visit nearly 200 million homes during Christmas Eve.

Timing

Let's assume Santa distributes gifts from 5 pm to midnight, or for 7 hours. Due to the Earth's rotation, there is an overall time difference of 24 hours between different time zones, so we can therefore say that Santa has 31 hours to finish his work (assuming he logically travels east to west). Visiting 200 million homes in 31 hours means that Santa has to visit approximately 1586 homes per second. Thus, he has about 1/1600th of a second to do everything mentioned above such as parking his sleigh, looking for the right gifts, climbing down the sleigh and chimney, binge on snacks, fill the stockings, come up again and rush to his next stop.

Let's assume that each of these 200 million stops is evenly distributed around the earth (which we know to be false, but for our calculations we will accept). The surface area of the Earth is 196939900 square miles. We are now talking about approximately one mile per household. A total trip of nearly 200 million miles, not counting assorted pit stops for relief, feeding, etc.

This means Santa's sleigh is moving at nearly 1800 miles per second, over 8000 times the speed of sound. In comparison, the fastest man-made vehicle on earth, the Ulysses space probe, moves at a poky 27.4 miles per second. A conventional reindeer can run, tops, 40 miles per hour.

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Weight

If every one of the 200 million homes with good children were to put out a single chocolate chip cookie and an 8 ounce glass of 2% milk, the total calories (needless to say other vitamins and minerals) would be approximately 225 calories (100 for the cookie, give or take, and 125 for the milk, give or take). Multiplying the number of calories per house by the number of homes we get the total number of calories Santa consumes that night, which is approximately 45,000,000,000 calories. To break it down further, 1 pound is equal to 3500 calories. Dividing our total number of calories by the number of calories in a pound and we get the number of pounds Santa gains, 12,857,143, which is 6429 tons.

The payload of the sleigh adds another interesting element. Assuming that each child gets nothing more than a medium sized Lego set (two pounds), the sleigh is carrying over 600 thousand tons, not counting Santa himself.

On land, a conventional reindeer can pull no more than 300 pounds. Even granting that the "flying" reindeer could pull ten times the normal amount, the job can't be done with eight or even nine of them -- Santa would need 413,000 of them.

This increases the payload, not counting the weight of the sleigh, another 52,000 tons, or roughly seven times the weight of the Queen Elizabeth (the ship, not the monarch).

Speed

600,000 tons traveling at 1800 miles per second creates enormous air resistance -- this would heat up the reindeer in the same fashion as a spacecraft re-entering the earth's atmosphere. The lead pair of reindeer will each absorb 26 QUINTILLION joules of energy per second. In short, they will burst into flame almost instantaneously, exposing the reindeer behind them, and create deafening sonic booms in their wake. The entire reindeer team will be vaporized within 4.26 thousandths of a second.



Santa, meanwhile, will be subjected to centrifugal forces 17,500 times greater than gravity. A 250-pound Santa (which seems ludicrously slim) would be pinned to the back of his sleigh by 4,315,015 pounds of force. This means that just starting and stopping his sleigh exerts a force on Santa that's the equivalent of stacking three Empire State Buildings on top of him.

Conclusion

The conclusion many people make is that if Santa Claus ever did deliver presents on Christmas Eve, he's dead now. However....

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Another Conclusion

Of course, these results would apply only in Newtonian space. Things get quite different when you bring Einstein and relativity into the picture. For that, we need to introduce the concept of "relativity clouds":

Santa's society of elves has at least five hundred uninterrupted years to evolve socially and intellectually. Their understanding of physics and engineering exceeds our own. To deliver presents in a single night, Santa and his elves would have researched a means to create more time. They recognized that time itself can be stretched like a rubber band, that space itself can be squeezed like an orange, and that light itself can be bent (based on general relativistic principles). It is thought that the first breakthrough came when they learned how to control time, how to control space and how to control light. They would have created "relativity clouds."

In contrast with Santa's five hundred years of understanding general relativistic principles, our understanding spans less than 100 years - and it's incomplete. We haven't unified the electrical and gravitational forces, nor resolved issues associated with wave-particle duality, nor examined singularities and other dramatic curvatures of space-time that could be used to manipulate space-time.

Relativity clouds are controllable domains (volumes) within which space-time is controlled. An observer inside a relativity cloud perceives time, space and light differently than an observer outside the relativity cloud. Inside the relativity cloud, Santa has months to deliver presents. Santa sees the world frozen and only hears silence. Upon returning to the North Pole, and leaving the domain of the relativity cloud, only a few minutes go by. The presents are truly delivered in the wink of an eye.

However he manages to do it, Santa sure has overcome some tremendous technical obstacles! And yet all over the world, children still manage to receive both love *and* presents this time of year. So may peace and joy be with you during this holiday time, no matter how you choose to celebrate it.