Design Graphics Team Project
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Reverse Engineering a Toy Nerf Gun

Nerf Rebelle

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We were charged to redesign a component of our Nerf gun in order to improve it according to our own judgement. For this we selected the vacuum pump spring (**Figure 1**) to redesign, and we identified the problem as a slow bullet speed resulting in inaccuracy at long distances. We decided to alter the vacuum pump spring since the potential energy stored in it by the consumer is the primary source of the bullet's speed. In order to improve our chosen aspects— bullet speed and accuracy— we decided to increase the length of the spring. Increasing the unstretched length of the spring allows the consumer to compress it a greater distance, in turn increasing the potential energy stored in it. Initially the length of the spring was 2.93 inches. For our redesign we did not want to increase the length of the spring too dramatically, but we did want to ensure there would be a noticeable difference. In redesigning the spring (**Figure 2**) we increased the length by 0.37 inches so that the new length was 3.3 inches.

The improvement expected with the increased length redesign of the vacuum pump spring is an increase in bullet speed and accuracy at longer distances. To make this work, one has to consider how the change could affect functions not targeted by our redesign effort. Effects the change would hold on other parts include more stress on both ends of the spring when pulled. These neighboring parts and interacting parts will deal with an increase in stress and may need to be redesigned to take the increased force and continue their function. When the new spring is resting, it will have a longer length at its equilibrium - increased by 0.37 in - and will need more room within the casing to avoid adding stress to the system while resting and so the spring's potential energy can be fully taken advantage of. What the change would mean for the user is more force needed to pull the shaft down. The reasoning behind this is that the distance compressed on the original spring (**Figure 1**) is much more than the distance compressed of the redesign (**Figure 2**), which is what makes the force F=-kx (x is distance compressed/stretched) required to pull the shaft and the force on interacting parts increase.

We wanted an increase in speed through the potential energy, and the spring meets those needs. The increase in distance compressed increases the potential energy U=1/2kx^2 (x is distance compressed/stretched). That increased potential energy equals the full kinetic energy, proportionally increasing the speed of the bullet with the equation K=1/2mv^2, naturally increasing accuracy at larger distances along with it (less time in the air for gravity to pull it down).

Figure 1 - Original Design of the Vacuum Pump Spring

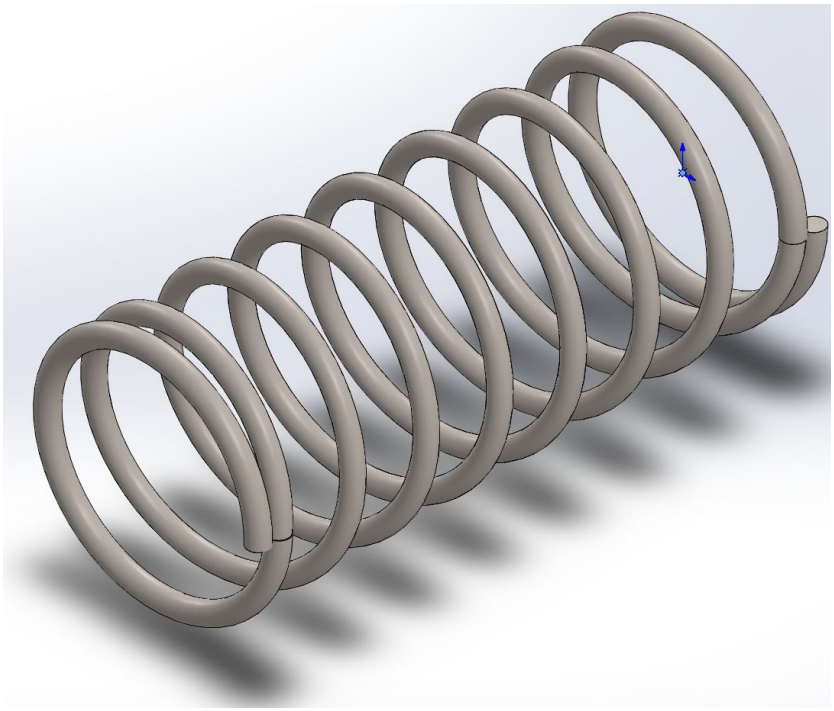

Figure 2 - Redesigned Vacuum Pump Spring