

The "Gauss Rifle"

Ready... Aim... Fire! But this gun sets off no explosion; instead, the ball flies off the end, propelled not by heat or rapidly expanding air, but magnets! Meanwhile, the ball "fired" sits at the back, behind the very first magnet in the string. But how?

Simple materials make up a working Gauss Rifle: a ruler, several magnets, and balls made of a magnetizable metal with a diameter about equal to the size of the magnets.

Twice as many balls as magnets are needed for the initial set up, and then one more ball to release in order to fire the gun. The magnets are tightly fixed to the ruler, and the balls lined up such that two follow each magnet on the front sides. Then the one extra ball is released from behind the first magnet, and within a few seconds, the front ball flies off the front!

When the "fired" ball is released, the attractive force of the first magnet pulls it forward, and the ball speeds up until it hits the magnet. The energy from the ball's speed must go somewhere, and so it transfers to the front ball of this set, on the other side of the magnet. This ball in turn flies off, speeding up as it approaches the second magnet, which it hits. The energy from this collision sends the furthest forward ball of this set moving towards the third magnet, and so on. With each successive magnet, the speed of the ball as it flies off increases. With only a few magnets, the last ball can leave with enough speed that the human eye cannot follow it.

The energy in the Gauss Rifle comes from the second ball following each magnet moving from a position of higher energy to lower energy. The first ball in each pair touches the magnet, and thus cannot move any closer. However, if it were taken out, the second ball would roll to touch the magnet. In the final configuration of the gun, there are the same number of balls, but all of the balls are directly touching a magnet, with none separated from the magnet by another ball. With no balls in the higher-energy state of separated from the magnet, the total energy of this system has decreased. The energy, in turn, had to go somewhere, and it went into the ball that left the front of the gun. This ball had as much kinetic energy as the gun lost potential energy, counting the potential lost as the first ball moved forward to touch the first magnet. Since quite a bit of potential energy can be stored in the starting configuration, giving moderately strong magnets, the front ball can leave at quite high speeds.

Bibliography

Field, Simon. "The Gauss Rifle: A Magnetic Linear Accelerator." [Science Toys You Can Make With Your Kids](http://www.scitoys.com/scitoys/magnets/gauss.html). October 21, 2005.

<http://www.scitoys.com/scitoys/magnets/gauss.html>.