

## Gauss Magnetic Accelerator #MAGLINE-01

### Warning:

- **Not a toy; use only in a laboratory or educational setting.**
- **Contains small parts.**
- **California Proposition**



**65 Warning: This product can expose you to chemicals including styrene, cobalt, nickel, and lead, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).**

### Introduction

Our **Gauss Magnetic Accelerator** is an incredibly simple device for demonstrating conservation of momentum, potential and kinetic energy, and magnetic force. This device was invented by the famous 19th century German mathematician Carl Friedrich Gauss. His work with magnetic forces was revolutionary, and some of that work can be seen with this demonstration.

With just two magnets and five steel ball bearings, you will be able to use this device to explore how energy is transferred. If you start by simply rolling one bearing down an unobstructed track, you will notice that it slows as it rolls towards the catch basket. This deceleration is

due to friction from the track and air. However, when you include magnets and additional bearings on the track (as shown in the photo below), the final bearing on the track will actually be moving faster than the trigger bearing you rolled manually into the first group of magnets and bearings to start the chain reaction of collisions.

You can use this device to observe **kinetic energy**, **potential energy**, the **conservation of energy**, and the **conservation of momentum**. When the trigger bearing (the leftmost bearing in the photo below) rolls towards the magnet of the nearest grouping, you can observe two forms of energy – the trigger bearing has **kinetic energy**, or energy in motion, because of the energy you transferred to it when initiating the roll, and, when it enters the magnetic field of the magnet, you can observe the stored **potential energy** of the magnetic field of the magnet transform into an increase in the bearing's kinetic energy as it pulls the bearing in for a collision. The **law of conservation of energy** can be seen by the transfer of energy during the collisions. Energy from any bearing crashing into a magnet is nearly perfectly transferred from one bearing, through the magnet it collides with, through the bearing touching the magnet, and then through the second bearing as it is sent rolling down the track. The **law of conservation of momentum** can be recognized by observing that the direction of the acceleration of the bearings remains the same as energy is transferred down the track.

The instructions on the next page will tell you how to use this device and examine the above process for yourself.



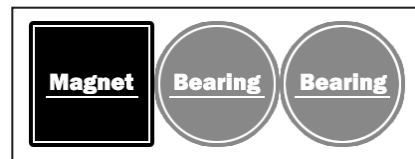
## Simple Launch Experiment

Follow the instructions below to quickly set up and use your accelerator:

1. Set your device onto a flat surface.
2. Adjust its feet to assure that the track is level. They should be equally spaced so that the track doesn't bend or warp when the balls are launching.
3. Gather your bearings and magnets into two groups containing one magnet and two bearings. You should have an additional single bearing left over. We will refer to this bearing as the "trigger bearing."

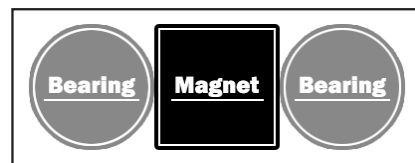
4. Place each of your two groupings onto the track in the arrangement shown in the image to the right:

(Note: The bearings in each grouping should be on the sides of the magnets facing the catch basket.)



5. Place your trigger bearing on the track farther away from the catch basket than either of the groupings.

6. To initiate the magnetic acceleration, roll the trigger bearing slowly down the track in the direction of the catch basket towards the nearest grouping. When it contacts the magnet of the nearest grouping, it will begin a chain reaction resulting in the high-speed launch of ball bearings towards the catch basket. If done as instructed, you will end up with one bearing in the catch basket and two separate groupings on the track in the arrangement to the right:



## Advanced Experimenting

In this section, I will go over options for experimenting that you can do if you want to manipulate variables on the track and observe measurable differences in acceleration. (Note: You will require two supplies [not included with this device] to complete this experiment: **one timer** and a set of **two photogates**.) The instructions are as follow:

1. Set up the device as described in steps 1 – 5 above.
2. Attach one photogate to the track between the trigger bearing and the first grouping, and attach the second photogate between the last grouping on the track and the catch basket. Plug your photogates into the timer.
3. Turn your timer on and launch the bearings on the accelerator as described in step 6 above. Take note of the speeds of the trigger bearing and the launched bearing.
4. Manipulate the following variables (one at a time) to observe their effects on rates of acceleration:
  - **Distance Between Grouping:** Take note of the distance between your two groupings to see how it effects the acceleration.
  - **Speed of Trigger Bearing:** Vary how quickly you roll your trigger bearing into the first grouping.
  - **Additional Groupings:** If you own additional magnets and bearings, experiment to see how the use of more than two groupings changes acceleration.