



# SOCIETY OF PHYSICS STUDENTS

An organization of the American Institute of Physics

## SPS Chapter Research Award Proposal

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| Project Proposal Title | Freshman Project: Electromagnetic Kinetic-Projectile Launcher |
| Name of School         | Georgia Institute of Technology                               |
| SPS Chapter Number     | 2361  |
| Total Amount Requested | \$707.74  |

### Abstract

The first-year students of the SPS chapter at the Georgia Institute of Technology are constructing an electromagnetic kinetic-projectile launcher (colloquially and henceforth known as a “coilgun”) in an effort to demonstrate the fundamentals of electromagnetism and kinematics to students in classrooms and through outreach programs in an engaging and interactive way.

# Proposal Statement

## Overview of Proposed Project

This project focuses on the issue of how to effectively illustrate fundamental principles of physics through interactive demonstrations in classrooms at Georgia Tech and in demonstrations at surrounding schools and outreach programs. In addition to pedagogical motivations, this project will center around the engineering of a safe, compact, and relatively simple electromagnetic kinetic-projectile launcher, giving the project members valuable experience in project design. This project has three main goals: the application of introductory physics concepts in order to construct a working coilgun, the use of the device as a teaching tool for introductory physics concepts, and outreach to incite excitement in students for STEM-related careers, with the emphasis on Physics.

In drafting the Freshman Project, we devised several ideas, but throughout the planning process we struggled to find a tangible purpose. Finally, a railgun was suggested with the purpose of outreach, a rather noble cause we could all agree on. After extensive research on the workings of a railgun, we decided a railgun had too many hazards associated with it and opted to change to a coilgun, a much safer alternative. Given the fact that several members of our team have experience with projects similar to the coilgun, it seemed like a very good contender for a group project. The fact that much of the Physics behind it are grounded in kinematics and electromagnetism, topics covered in introductory Physics courses here at Georgia Tech, have also made us confident in our ability to complete this build beyond our expectations, but at the same time we acknowledge this project will not be an easy one.

This project will strengthen both the National SPS program as well as our chapter. Having an interesting and fun demonstration to show outside members and younger children interested in science will work well to garner interest for both physics in general and SPS specifically. Having more people exposed to SPS at Georgia Tech will increase participation and membership for our local chapter and therefore help the national chapter as well.

## Background for Proposed Project

The purpose of this project is to construct a working coilgun. A coilgun, also known as a Gauss gun, is a device that utilizes the properties of a solenoid electromagnet in order to propel a ferromagnetic projectile. By timing the precise on-time and off-time of a series of solenoids, the projectile is propelled forward due to induced ordering of the ferromagnetic domain. This causes the projectile to exhibit its own magnetic field and thus be propelled by the magnetic force. The solenoids (if several stages are used with less power instead of a single stage at higher power) must be timed to turn off and on or else there is a loss of kinetic energy as the magnetic force pulls the projectile backwards upon passing the center of the solenoid. From here on the projectile gains speed until exiting the series of coils.

At Georgia Tech, the Physics department strives to provide its students with the skills necessary to become the next great wave of professionals. By instituting the Freshman Project, Georgia Tech and its chapter of SPS allows students to work as a group to achieve a common goal, provides students with the opportunity to get hands-on learning experience, and lets us apply learned concepts to real world applications. While our primary goal with this project is to build a device that can demonstrate the topics discussed in Georgia Tech's introductory Physics classes, kinematics and electromagnetism, this build is intended to spark interest in the introductory course students. It is with outreach in mind that we hope to make this coilgun.

## Expected Results

At the end of the project, we expect to have have a fully functional coilgun capable of firing projectiles approximately 20 meter per second. This is fast speed to fire the metal ball bearings, but it will be under supervision and many trials will be conducted to insure safety. Firing them fast also makes the demonstrations for introductory classes and surrounding outreaches programs more captivating. The project is expected to pique interest in students already at Georgia Tech and students in grade school who may be interested in physics.

## Description of Proposed Research - Methods, Design, and Procedures

The coilgun is, after production, primarily going to be used for demonstrations in class on and off campus. Because of this, the coilgun will have to be fairly portable and easy to take from class to class and to other schools for outreach programs. The shooting of the projectiles also needs to be very visible for the audience, so targets such as plastic bottles or aluminum cans will be used.

Our coilgun will be constructed from the following major components:

- The solenoid series: several magnet wires wrapped in a cylindrical-spring shape. The solenoids, once an electric current is run through them, will provide a magnetic force on the ball bearing in single direction out of the coils.
- Capacitor banks: will build up a large amount of electric charge and dispel it at one time for a large, controlled current in the solenoids, inducing the magnetic field and firing the projectile.
- Batteries and circuitry: will be used to power the solenoids, connect all the parts to insure proper timing of the current activation, and for constructing various fail-safes and safety measures.
- The treated wood: will be used to construct a housing to safely hold all the parts in a heat-resistant and electrically-resistant structure.
- The ball bearings: will be the ferromagnetic projectiles fired from the coilgun.

## Plan for Carrying Out Proposed Project

**Personnel:** The main project members consist of seven SPS first year students at Georgia Tech. Other first years in SPS will be helping out when they are available and have spare time.

**Expertise:** Sujeeth Jinesh, the leader of the SPS freshmen project, is ahead in his classes and already has knowledge of electricity and magnetism and circuitry to use when making the coilgun. Zachary Kennedy worked at Southern Advantage Electronics for two years and has the electronics expertise necessary for the circuits and wiring.

**Research space:** For a space to research and work on building the coilgun, one of the research labs in the Howey Physics building on Georgia Tech's campus will be used, possibly room S203. It will be done after normal classroom hours so we will not be interrupting any normal classes.

**Contributions of faculty advisors or the department:** The project will be designed and conducted primarily by the core group of students mentioned above. If faculty assistance is required, Dr. Ed Greco has agreed to be our faculty advisor for the project.

## Project Timeline

Project timeline:

- January 11- Spring 2015 semester begins
- January- Finalize designs
- February- Buy all parts and finish designs
- March- Begin fabrication of coilgun
- April- Continue fabrication of coilgun

May- Finish fabrication of coilgun and submit interim report

August- Test and refine finished product

September- Have final working coilgun

October/November- Demonstrate final coilgun to introductory physics classes

December- Write final report to SPS National

## Budget Justification

The grant money from SPS will be used solely to buy all of the parts necessary to to build the coilgun. This encompasses items such as copper magnet wire, circuitry (transistors, resistors, switches, capacitors), and batteries. A housing to safely hold the coil gun will be constructed from treated wood. If money cannot be gotten from SPS, we will attempt to get some from Georgia Tech's Student Government Association, and after that, the physics department.

## Bibliography

- "Operational Requirements and Issues for Coilgun Electromagnetic Launchers." IEEE Xplore. N.p., n.d. Web. 15 Nov. 2015.
- "Design." DeltaV Engineering. N.p., n.d. Web. 15 Nov. 2015.
- "Practical Coilgun Design." Theory. N.p., n.d. Web. 15 Nov. 2015.