CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Thea Adumitroaie

Project Number

34859

Project Title

Diamagnetic Levitation of Pyrolytic Graphite and Young Humans (Could We?)

Abstract

Objectives/Goals

My research project was aimed at finding the effect of levitating mass and external magnetic field on the levitation height of a diamagnetic sample, and estimating the magnitude of the magnetic field required to float a young human.

Methods/Materials

The main items in my experiment were 64 rare-earth alloy ($Nd_2Fe_{14}B$) permanent magnets, each being of 6mm sized cube and N48 grade; 3 pyrolytic graphite (a strongly diamagnetic material) sheets, 25mm x 25mm x 1mm thick, which were cut along thickness. The best identified magnet configuration (alternating poles) was scaled down to a 4x4 magnet layer and used to levitate different masses and sizes of graphite samples. The levitation height in each setup was measured on a 1mm x 1mm printed grid. I repeated the measurements for increasing numbers of magnet layers. To explain the latter effect, I used a magnetic field computer simulation program. I also derived an expression for the magnetic field, from force equilibrium conditions. Using a simple geometric model of my body and assuming a 70% content of water (a diamagnetic substance), I estimated the magnetic field needed for me to levitate.

Results

As expected, the levitation height was found to be inverse proportional to the diamagnetic mass, given a constant surface area. Adding multiple layers of magnets produced no visible change in levitation height, which, at first, was puzzling. Using a magnet computer model, I calculated that there should be at most a 15% change in the magnetic field, which translates to a maximum 0.3 millimeters increase in levitation height. This change was unnoticeable by unaided visual observation. Finally, 85 Tesla (1.7 million times stronger than the Earth's magnetic field around my house) are required for me to float.

Conclusions/Discussion

Diamagnetic levitation can be analyzed successfully using a combination of experiments, physics modeling, and computer simulation. My hypothesis was correct, in that both sample mass and external magnetic field strength affect the diamagnetic levitation height, but I discovered that sample surface area (at constant thickness) is an independent variable as well. In the current setup, finer measurement techniques are needed to describe the effects more accurately. Levitating humans in magnetic fields seems to be a feasible activity, but not necessarily a healthy one.

Summary Statement

In this project, I was able to analyze diamagnetic levitation of graphite and young humans using a combination of experiments, physics modeling, and computer simulation.

Help Received

Father helped with cutting the graphite sheets and explaining the physics formulas.