HWJS

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NASA, ESA, and J. Jee (University of California, Davis)

Graphene: the Super Material
Approximating the Unsolvable
Such Synchrony, in Reality

JUSTIN BAE

Studies in Scientific Research teacher **Antonio Nassar**, right, works with his students on a project. Nassar has been teaching the class for 10 years.

JOURNAL NOTES

Free, Playful and Kinder Spirit: Essentials of Science Research from Feynman, Rohn to Lyubomirsky

BY ANTONIO NASSAR, SSR TEACHER

Above all, we need to promote free spirit, perennial curiosity and playfulness in our science classes because these are key components that can inspire a future Nobel Prize winner.

Physicist Richard Feynman said that the essence of doing science research is: "Guess, compute consequences and compare to the nature or experiment." In general, science research implies deep investigation, probable dissent, continuous fact-finding, close analysis, constant reevaluation and critical thinking. In particular, one needs to have perennial curiosity, to endure setbacks and frustrations, to keep impartiality, to stay focused on the project and to be open-minded for all outcomes and above all to be playful: a free spirit.

NATHANSON'S

Antonio Nassar

On the other hand, Dr. Jenny Rohn (a cell biologist at University College London) says that she's been riffing off obscure old papers that no one gave any credence to at the time, and that took decades to click into place with the shifting context of knowledge. There will always be a place for eureka moments and individuals of extraordinary insight and talent — but although they are not as celebrated as Richard Feynman, the rank and file are just as important. Great science doesn't necessarily come from hard work, rather the striking advances come from people on the fringes, being playful: a playful spirit.

Further, Dr. Sonja Lyubomirsky (a psychologist at University of California, Riverside) says that for one to stay happy in doing research one should set flexible, optimistic goals, positive scenarios, and to support emotionally and express kindly your own agreeable or dissenting ideas with your research partners: a kinder spirit.

These constitute the essentials of our Studies in Scientific Research: Free, Playful and Kinder Spirit.

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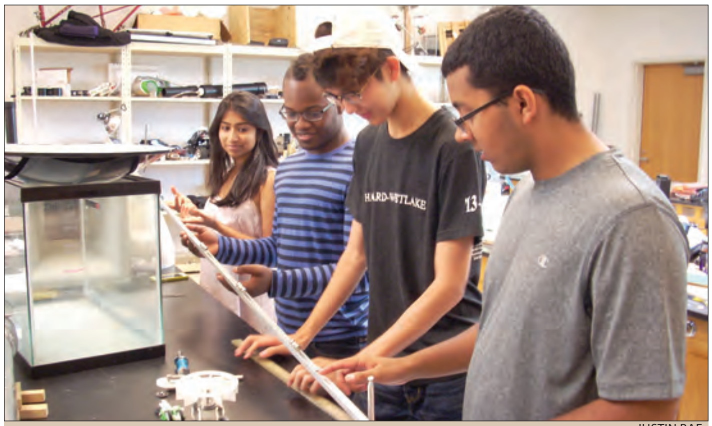
Kevin Zhang '14, left, **Nima Shamtoub '14, Patrick Angelo '14** and SSR teacher **Antonio Nassar** work on building a quadcopter for a project.



JUSTIN BAE

Divya Siddarth '14, left, **Donhem Brown '14, Henry Jiang '14** and **Ojas Parashar '14** work on rail gun as part of Parashar's project.

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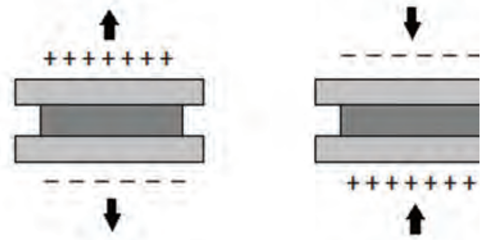
STUDIES IN SCIENTIFIC RESEARCH PROJECT

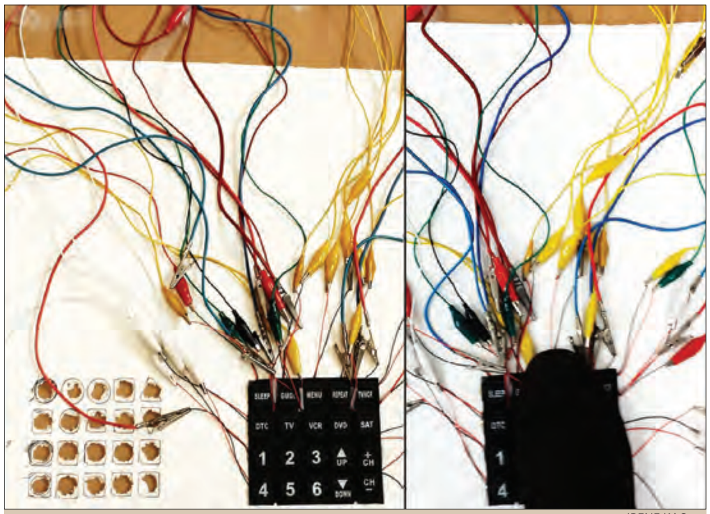
Harvesting Human Energy Using Piezoelectricity



BY HENRY JIANG AND IRENE KAO

The modern world relies heavily on non-renewable energy sources such as coal, oil and natural gas. One potential solution to the energy problem is to harvest human power, considering that a large amount of human energy from daily functions such as walking is lost to the environment.

We are investigating methods that use piezoelectricity to harvest energy from human footsteps. We attempted to counteract several problems that piezoelectric materials present, such as high cost, low energy output and fragile materials. Using simple piezoelectric discs made of lead zirconate titanate (PZT) and creative design, we were able to use footsteps to light LEDs. We found that applying mechanical compressions on a smaller surface area of the piezo material generated significant amounts of voltage, which we then directed to act as a power source.



IRENE KAO

Fig. 1: The PZT device is composed of a foam board with a hole, a small disc and a rubber button, left. One footstep covers at least 5 discs.

INTRODUCTION

Piezoelectric materials are spontaneously polar, or exhibit polarity without the application of an electric field. The piezoelectric effect occurs when mechanical stress induces a change in polarization by displacing the positive and negative elements of the dipole moment, generating an electric field.

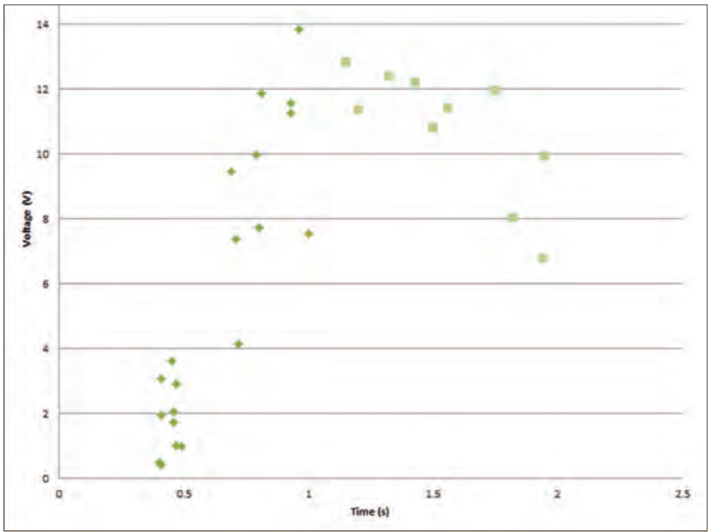
We wanted to develop a cost-efficient piezoelectric device with high energy output that uses human footsteps for powering meaningful applications. We sought to find solutions to the problems of low energy output, high cost and fragility that piezoelectric materials present. We decided to use discs made of the piezoelectric material lead zirconate titanate or PZT ($Pb[Zr_xTi_{1-x}]O_3$, $0 \le x \le 1$) for our project because it is a cheap and widely available material.

RESULTS

We compared the voltage generated by light compressions and quick taps on the PZT discs. Compressions showed a 19 ± 6.3-fold increase in voltage, with an average of 4.36 ± 1.10V, compared to quick taps that have an average of 0.23 ± 0.052V. In our observations, tapping the disc lighted LEDs faintly while compressing them increased the brightness.

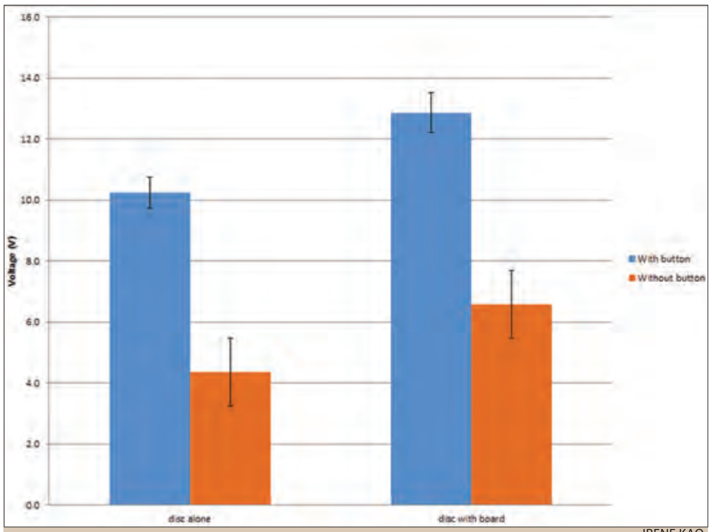
We discovered that using silicon rubber buttons to compress the PZT discs generated even more voltage, 2.4 ± 0.67 times more than compressions without buttons, with an average of 10.3 ± 1.33V. We designed a board that allowed for effective compressions. Compressions with the button and board showed a 2.0 ± 0.52 fold increase in voltage from compressions without the board.

To determine the relationship between the amount of mechanical stress applied and voltage generated for our device, we varied the time of mechanical stress application. As we increased the amount of time stress was applied, the voltage output also increased. However, at about 1.5 seconds, the voltage started to decrease, indicating that the optimum compression time for one disc is about 1.5 seconds,



IRENE KAO

Fig. 2: Voltage vs. amount of time stress applied on the device



IRENE KAO

Fig. 3: Voltage generated by PZT disc

IRENE KAO

Fig. 4: A foam board with a hole through it, left, a small installed disk and an installed rubber button make up the components of the PZT device.

producing a maximum of about 12-14V.

To determine the practical applications of our device, we recorded the voltage generated over three minutes of walking, stepping on the device at a rate of one footstep every five seconds. We generated a total of 257V or 85.7V per minute. We constructed a larger board to fit 20 small PZT discs. One footstep covers at least five of these discs, so one footstep can generate five times the voltage.

DISCUSSION

Piezoelectricity is not widely used for generating electricity because it seems that its energy-generating effects are very small. However, we have devised a cost and energy-efficient piezoelectric device that generates a significant amount of energy. In addition, we have successfully integrated our innovative idea of harvesting human energy using human footsteps, simply using human energy that is already being "lost" from walking rather than requiring additional energy to be expended.

Our final device cost no more than $30 and was comprised of 20 small PZT discs, a foam board and silicon rubber buttons. We determined that compressing, rather than hitting, the PZT discs generated a large amount of voltage. Thus, we cut shallow holes in our board to allow the PZT discs to compress sufficiently while still allowing the discs to withstand a lot of stress. We incorporated silicon rubber buttons that also increased voltage output. We believe that small discs, buttons and compression discs all work well because they distribute the mechanical stress applied on the disc over the whole disc, increasing the disc surface area to mechanical stress ratio. The effects of all the discs combined can all together generate a large amount of energy.

Our device can be incorporated in "walking cities," such as New York city, and connected to city lights or power grids to help power the city. Theoretically, if half of New York city's population, four million people, took 10-minute walks a day, they could generate at most 34.3 billion.

METHODS

We designed a device that incorporated footsteps effectively, withstood high stress and maximized energy output. During the design process, we collected data on the different designs' ability to light LEDs and their voltage output. We tested our device with footsteps to determine its practical applications.

To build our large device that covers on foostep, we cut 20 holes, 4x5, about 15mm in diameter and 5mm apart from each other on a 0.4mm thick foam board. We then taped down one 20mm PZT disc on top of each hole and secured the rubber keypad on top.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

How to Build a Quadcopter

BY PATRICK ANGELO, NIMA SHAMTOUB AND KEVIN ZHANG

In our Studies in Scientific Research class, we have attempted to construct a copter with four propellers that can fly under the direction of a remote. We may go on to modify it to our satisfaction; this may include the addition of solar cells, which will allow for the quadcopter to recharge its own battery during flight, as well as the potential supplementation of mechanical programming so as to allow for the copter to perform interesting (and cool) functions. We have already researched the parts required to construct the copter, and are already nearly complete with assembly. What remains is to research and incorporate individual parts (such as the solar cells) and the programs we will eventually choose to apply to the copter. The final matter, which will be resolved after completion of research and incorporation of the aforementioned aspects, will involve learning how to fly the actual quadcopter using a transmitter. Quadcopters improve upon normal helicopters due to their unique abilities to expand maneuverability beyond the standard helicopter model, as well as further enhance stability and safety. Quadcopters can also be used under circumstances in which the standard helicopter may be unable to operate; the compact rotors of a quadcopter allow for a smaller footprint, allowing it to be significantly more maneuverable when necessary.

GOAL

To learn to build a quadcopter and modify both the functionality and efficiency with solar panels and programming, functionality and efficiency.

PARTS FOR ASSEMBLY:

- Circuit Board (KK 5.5)
- Mounting Plates (Bumblebee kit)
- Rotors and Props (4x)
- Three-pin wires (4x)
- Electric Speed Controls (4x, combined in a Quattro 4x20A ESC)
- Battery (Lithium-ion 3300 mA)
- Landing Arms (Bumblebee kit)
- Turnigy 9x 9Ch Transmitter

PATRICK ANGELO

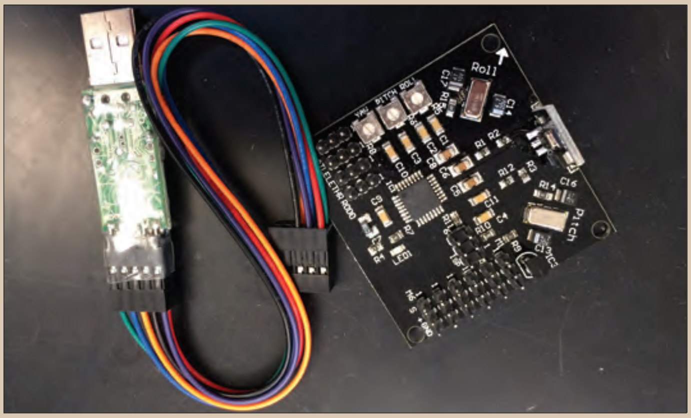
Kevin Zhang '14 finishes up the assembly of the motors on the frame.

- Turnigy 9x 2.4 Ghz 8Ch Receiver
- USBasp module
- Misc. (zip ties, screws, duct tape, etc)

Because we needed to mount the circuit board on the bottom of the copter and the frame was too short, we attached two screws to the end of each arm to raise the copter about an additional 3cm off the ground. We have been able to connect the motors to the circuit board by stripping each individual wire of about 2cm of insulation and soldering the ends together. These soldered ends were covered (to prevent damage, wearing, and electrical shorting) with shrink wrap, that was then shrunk through heat to fit comfortably around the soldered sections. After this, we managed to get the circuit board working (which is attached to the bottom of our copter) by attaching a battery to one of the three-pin connections on the circuit board, and attached the electric speed controllers to the circuit board using four more three-pin connections.

We have also configured the transmitter so as to be able to control the flight of the copter. The original circuit board fried from an excess of electrical current, so we replaced it with an updated model, the KK 5.5. We then programmed and updated the soft-

STEP-BY-STEP



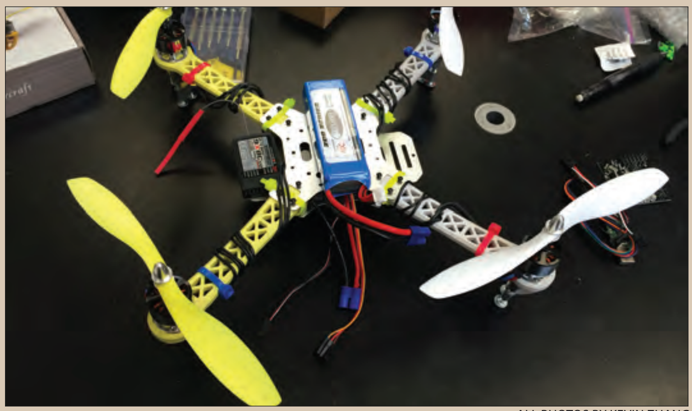
The circuit board, right, and the USBasp device used to program it.

The Turnigy TGY 9X transmitter used to control the quadcopter as a whole.

STEP 1: The bottom of the quadcopter by the end of the first semester.

STEP 2: The quadcopter with the original board at the end of first semester.

STEP 3: Wires used to connect the motors to the circuit board.



ALL PHOTOS BY KEVIN ZHANG

STEP 4: The nearly-completed quadcopter after first semester.

ware on the KK 5.5 using a device called a USBasp, the USBasp driver and the KK Flash Tool, which allowed us to configure the KK 5.5 to support four-rotor copters. In the process, we were also required to bind a receiver called the Turnigy 9x 2.4 Ghz 8Ch Receiver to our Turnigy 9x 9Ch Transmitter; after doing so, we attached the Turnigy Receiver to our KK 5.5 using several three-pin connectors. As for configuring the transmitter and receiver, we must first finish assembling and programming the copter; only after doing so will we be able to test properties of the copter like yaw, thrust and other factors. We also plan on potentially adding solar panels to make it a self-sustaining model.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Approximating the Unsolvable

BY AARON ANDERSON, DANIEL PALUMBO AND DIVYA SIDDARTH

Numerical integration is the process by which sets of differential equations with no analytic solutions may be approximated using given values for initial conditions followed by exhaustive calculation over many small intervals.

In this application, gravitational and electric fields created by an initial set of N bodies are approximated and visualized by software we created using Python's visual module and extension, VPython. The program serves as both a scientific tool and a teaching resource, complete with error propagation and sophisticated, user-friendly input and output.

Numerical integration is an old solution to an even older problem, originally posed by Newton, as he tried to mathematically describe the motion of the sun, the moon and the earth. Finding that calculus failed to find solutions for position as a function of time, he simply provided diagrams and explanations that would leave the newly dubbed "N-body problem" untouched for a century.

One hundred years later, Euler approximated the positions of N bodies at a given time by calculating initial forces with given values for position, velocity and mass, applying these forces for a small interval of time, then repeating the same process until a desired time was reached.

While other methods of integration have emerged that are of a higher order description of the particles, the differences in the number of calculations and in the accuracy of the simulation are highly dependent upon the initial conditions of the system, and thus no general choice between the two methods can be made.

Our decision to use VPython's visual module for simulation appears to have been a wise one, as we currently have visualization and calculation of movement in three-dimensions functioning correctly using Euler's method of numerical integration. TKinter implementation of data input and output allows smooth communication between the program and user.

One major issue lies in handling collisions. On scales that are planetary or greater, treating collisions as inelastic adequately models collisions between particles, and this is currently working as intended. More difficult, however, is calculating trajectories resulting from two or more perfectly elastic colliding bodies (akin to an ideal gas model).

As can be proven algebraically, perfectly elastic collisions in three dimensions do not have a generalized unique solution for any two particles, and instead require experimentally determined coefficients of elasticity to determine trajectories resulting from collisions. Thus, our numerical integrator has remained solely useful on the astronomical level.

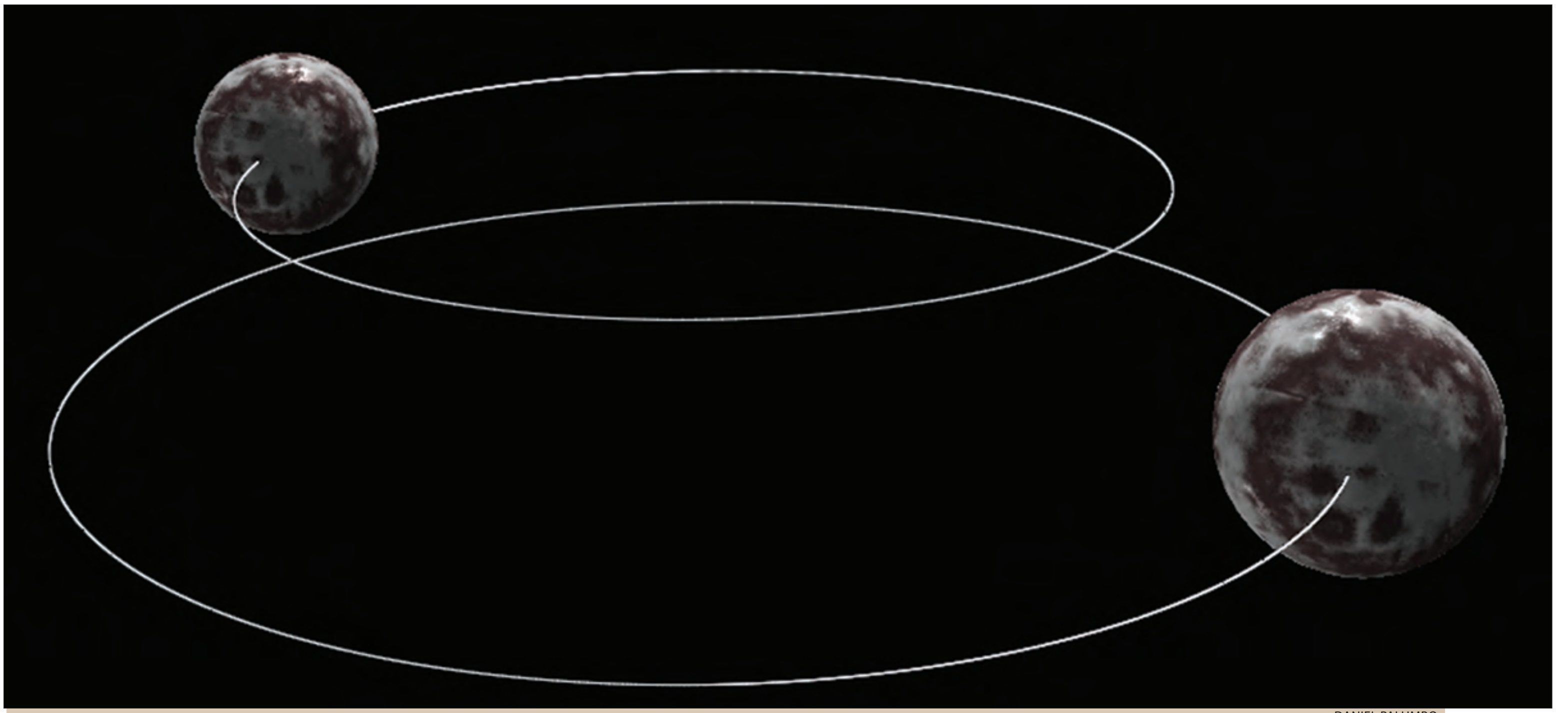
Another consideration necessary to creating the integrator is choosing the method of integration used. We could have possibly used an integration method of a higher order, like Verlet integration or even Runge-Kutta integration.

The Euler method, however, takes the least processor time, preserving efficiency, an equally important part of the program, which determines just how long a simulation will take to run to completion.

In systems with large numbers of bodies with long desired runtimes (like a simulation of the evolution of the solar system), simulation times can reach several hours. This is largely because most standard methods of numerical integration have efficiency of $O(n^2)$, meaning that runtime increases with the square of the number of acting bodies.

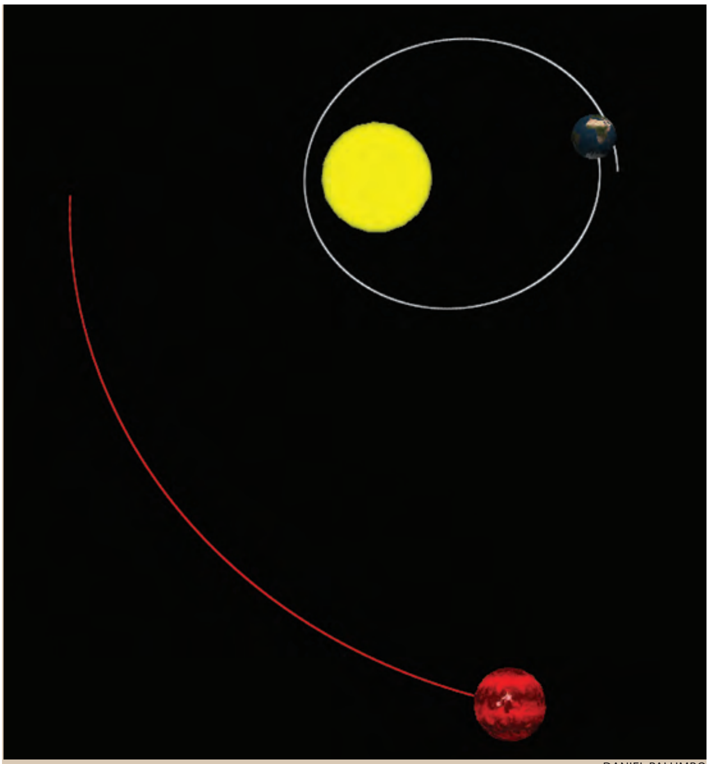
Alternative methods, like the Barnes-Hut method, use a tree structure for all members of the system, thus performing with an efficiency of $O(n \log n)$, though this is somewhat impractical for a system with no natural structural hierarchy with which to create a tree organization.

A system of linear efficiency $O(n)$ is only barely feasible, as it would require a threshold distance to be declared below which nearby bodies can be grouped



DANIEL PALUMBO

Fig. 1: A simulation of a stable binary system



DANIEL PALUMBO

Fig. 2: A simulation of a star system with two planetary-mass object and one stellar-mass object.

as one. In order to actually force the system to have this efficiency, the threshold distance would have to be so large that the accuracy sacrificed would far outweigh the benefits gained in reduced runtime. Thus, for now, we will continue with the current method due to its consistency and accuracy.

As a teaching tool, the numerical integrator can be used as a versatile demonstration of conservation of energy and momentum, as well as a foundational demonstration of chaotic systems. Various graphs can be made and compared using the data from the simulation.

For example, one can show that the sum of the kinetic energies and gravitational potential energies of all bodies in the system always has the same value, or that the total momentum of the system is always the same, while simultaneously monitoring the individual energies and momentums of each body.

As a scientific tool, numerical integrators such as these can be used to model the possible pasts and futures of classical systems.

Specifically, numerical integrators are excellent tools for modeling stellar systems, where initial conditions are well known and relatively easily measured.

Thus, numerical integrators may inform us of both the evolution and far future of our own solar system. Further, numerical integrators can test theories on grand scales (for example, the behavior of dark matter) by implementing the theory in the program and comparing it with observation.

Updates accounting for elasticity, variable density,and improved graphics are our current goal. We hope that the numerical integrator is found useful, and look forward to continuing our work in the future.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

The Antikythera Mechanism: A Device Before its Time

BY BEN GREENE AND JACQUELINE RIDGLEY

AN UNEXPECTED DISCOVERY

Discovered in a shipwreck off the coast of Antikythera, an island midway between mainland Greece and Crete, the antikythera mechanism went neglected for over half a century. It wasn't until the seventies when researchers could utilize X-ray tomography that the mechanism gained much recognition.

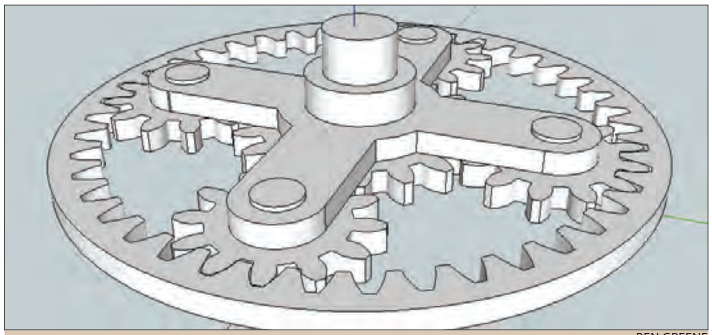
The antikythera mechanism (hereon referred to as the mechanism) is an ancient Greek planetarium, unique in that it predates other computational and horological devices by about fifteen centuries. What makes the mechanism so impressive is the Greek's use of epicyclic gearing to illustrate the elliptical orbits of celestial bodies relative to the earth in a pre-Copernican era.

THE MECHANISM

The mechanism displays three dials: the solar calendar on the front, the Metonic and the Saros dials on the back. The dial faces were labeled with Greek instructions, illegible until scanning techniques improved. Hand-cranked input begins in the main Sun gear and undergoes several permutations to output the different features. The lunar and solar outputs are concentric, achieved by use of a tubular axle, in which a narrower axle turns at a different rate.

On the back, the Metonic dial illustrates the irregularities of the lunar month, which was 29.5 days long. The Saros dial accurately predicted eclipses for 19 years before it had to be reset.

Another feature that sets the antikythera mechanism apart is its use of epicyclic gearing. An epicyclic gear train consists of a set of gears that orbits another set of gears. The Greeks used this design paired with a pin-and-slot mechanism to illustrate the apparently elliptical orbit of the moon. The pin-and-slot mechanism uses an off-center gear held in



BEN GREENE

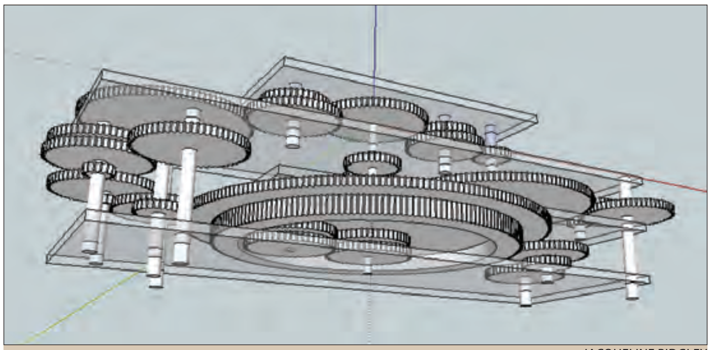
Fig. 1: A epicyclic gear train consists of a set of gears that orbits another set of gears. The Greeks used this design paired with a pin-and-slot mechanism to illustrate the apparently elliptical orbit of the moon.

place by the pin to create the perigee and apogee of the lunar orbit. Input comes from a tubular axle through which the output leaves.

There are two pairs of gears, each pair having the same tooth ratio. The e5 gear links with the k1 gear, mounted epicyclically on the e3 gear (concentrically), which receives input from an external source. The k2 gear is slightly off center from k1 and is held to the same angular velocity using the pin-and-slot coupling. K2 and e6, due to their larger radii, have larger circular pitches. The e6 gear in the train produces output through the tubular axle of the first gear.

DESIGN AND CONSTRUCTION

We plan to design and construct a replica of the antikythera mechanism. Currently, we are in the middle of comprehending and diagramming (both physically and virtually) the mechanism. Actual construction is somewhat challenging simply because horology is a highly trained profession; manual construction is out of the question, leaving 3D printing or laser cutting. We initially planned to use 3D printing, but since the digital files couldn't render true circles, difficulties would arise with the printer's resolution.



JACQUELINE RIDGLEY

Fig. 2: A three-dimensional model of the antikythera mechanism design created by Greene and Ridgley on the computer software Sketchup.

Currently, we are looking into Ponoko, a laser cutting company that can create the gears from digital files with a wider variety of materials – metal, wood, or plastic. For the initial model, we will use laser-cut wood for the gears and framework panels, differentiated by light and dark color wood. We will use a series of pipes and dowels, purchased from Kit Kraft, as axles.

We have concluded that the best design for our own mechanism will be the Carman, Thorndike and Evans model. Another model made by Michael Wright is similar in design to the Evans et. al model, but it also includes gear trains for the five classical planets.

Considering the complexity of the mechanism, we will refrain from including the planetary gear trains in our initial models, if at all. In our model, we expect to face some problems in assembly due to differences in circular pitch (essentially the tooth size) of several gears. This aspect affects the radius of a gear and its ability to mesh with other gears.

The Greeks crafted some of the gears with different pitches so that they would fit into the device – a decision that necessitates many calculations and some trial-and-error in the design and assembly of our version of the mechanism. Using the 3D modeling software Sketchup, we have created a virtual 3D model of the mechanism, retrofitted to our chosen design. Following this model, we will use Inkscape, an open source SVG graphics editor, to draw all the gears as 2D models in a digital file type that is accepted by Ponoko.

Recently, we finished the Inkscape designs for the gears, which cover eight panels in total. For the majority of the gears, we set the circular pitch to 22.3px (about 6.28mm), the diameter of the axle hole to 6.35mm, and the sheet thickness to 3.2mm. Two pieces — the sun gear (223 teeth) and the e3 ring (188 teeth) — were too large to fit on the panels. To work around this, we halved them and will print the panels twice on sheets that are 1.5mm thick, fitting them together by rotating one pair 90° and stacking it on the other pair.

In order to reduce mass and improve functionality, we designed spokes for some of the larger gears. We may come across discrepancies with measurements since the Inkscape plug-in for rendering gears required a conversion from millimeters to pixels.

Once we receive all the physical materials, we can begin constructing the mechanism.

REFERENCES

Carman, Christián C., Alan S. Thorndike, and James Evans. “On the Pin-and-Slot Device of the Antikythera Mechanism, with a New Application to the Superior Planets.”Journal for the History of Astronomy 43.150 (2012): 93-116. Feb. 2012. Web. 20 Oct. 2013. http://www2.ups.edu/faculty/jcevans/Carman%20Thorndike%20Evans.pdf.

Freeth, Tony. The Antikythera Mechanism: Decoding an Ancient Greek Mystery. Publication. University of Michigan, Sept. 2008. Web. 20 Oct. 2013. http://www.lsa.umich.edu/UMICH/classics/Home/News/Platsis%20Endowment/2008%20-%20Freeth,%20The%20Antikythera%20Mechanism%20Decoding%20an%20Ancient%20Greek%20Mystery.pdf.

Freeth, Tony, and Alexander Jones. “The Cosmos in the Antikythera Mechanism.” ISAW Papers 4 (2012). Http://dlib.nyu.edu/awdl/isaw/isaw-papers/4/. NYU Library’s Ancient World Digital Library, Feb. 2012. Web. 20 Oct. 2013. http://isaw.nyu.edu/.

Vicentini, Massimo Mogi. “The Antikythera Celestial Machine.” Http://www.mogi-vice.com. January 2012. Web. 25 Oct. 2013. http://www.mogi-vice.com/Antikythera/Antikythera-en.html.

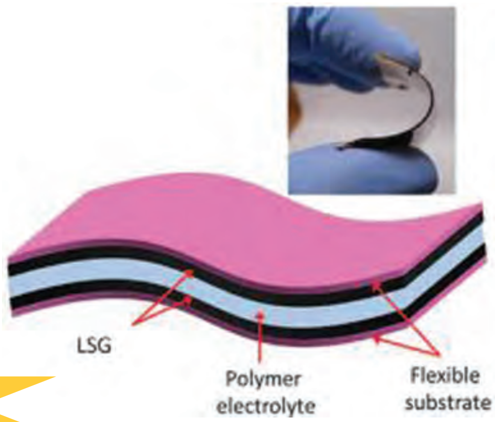
Wright, M. T. “The Antikythera Mechanism Reconsidered.” Interdisciplinary Science Reviews 32.1 (2007): 27-43. Print.

IMAGES

Antikythera Mechanism Research Project. “Computer-generated reconstruction of the front and back of the Antikythera Mechanism.” Photo. LiveScience.com. 5 Jan. 2013. 15 Nov. 2013. http://www.livescience.com/26008-diving-antikythera-roman-shipwreck.html.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Graphene: the Super Material



BY ANDREW FRIEDMAN AND MAC COLQUHOUN

Graphene is a single layer of carbon atoms organized in a lattice structure. Graphene is stronger than steel, is an extremely efficient super-capacitor and maintains perfect conductance even when bent. First described by Hanns-Peter-Boehm, who used transmission electron microscopy and X-ray diffraction to isolate and observe the material, it was only in 2004 that graphene was synthesized by researchers at Manchester University who used Scotch tape to exfoliate graphite and produce single layers of carbon. The discovery and popularization of this method was accompanied by new demand for the material. In 2012, a lab at the University of California, Los Angeles, led by Dr. Richard Kaner, developed a quick and efficient method for creating graphene super-capacitors. Researchers coated LightScribe compact discs with graphite oxide, exposed them to the drive's laser, and reduced the GO into graphene. Using the LightScribe drive also afforded the researchers a great amount of flexibility when producing graphene, giving them the ability to "print" capacitors of any shape. This method allows for low-budget graphene synthesis and is most feasible for high-school students to replicate.

The initial goal of our research was to synthesize graphene using Dr. Kaner's LightScribe method and to explore the applications of graphene for super-capacitors made using this approach. Due to the nature of this method, several layers of graphene are produced, so it therefore cannot produce pure sheets of monolayer graphene at this stage. In addition, the graphene is difficult to separate from the plastic surface it is "printed" on. Despite its limitations, the feasibility of the LightScribe method made it the most practical.

As stated previously, the method used to synthesize our graphite oxide was a modified version of Hummers' method. We did the following at 1/5th scale:

"In a typical reaction, potassium permanganate (15g) and expanded graphite (5g) were initially stirred until homogeneous. Then, in a bottom-round flask (500mL) with ice-water bath, concentrated sulfuric acid (98%, 100mL) was added to the

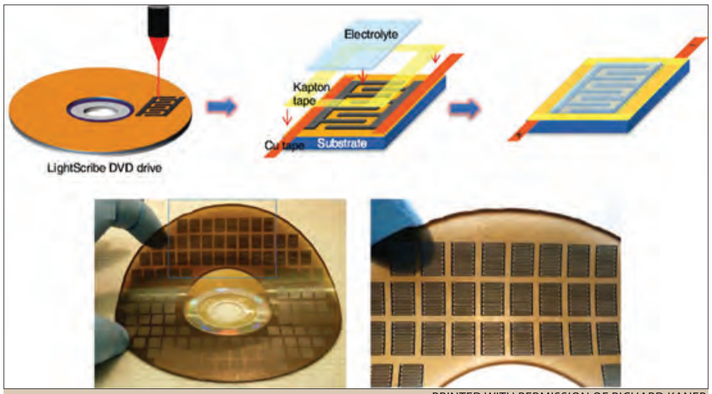


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Fig. 1: Rough outline of the method for preparing graphene capacitors

mixture with continuously stirring until a uniform liquid paste was formed. Then the water bath was removed. The stirring continued until a foam-like intermediate spontaneously formed (around 30 minutes) at room temperature with a large volumetric expansion. Deionized water (400mL) was added, and rapid stirring was restarted to prevent effervescing. Next, the flask was placed in a 90 °C water bath, and after one hour a homogeneous suspension was obtained that was dark yellow in color."

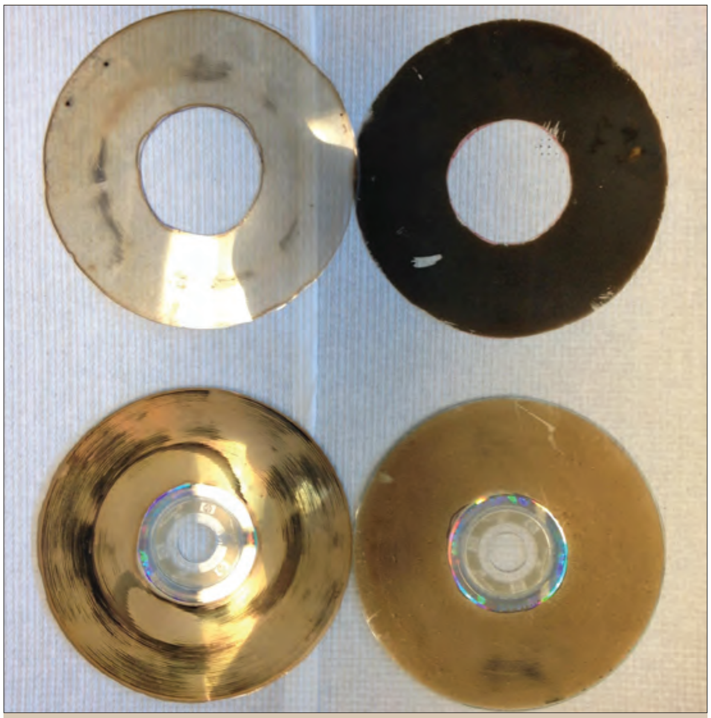
In preparation for the graphite oxide reduction, we attached thin plastic sheeting to the top of each LightScribe disc. This allowed us to remove any graphene that might have been produced during the process. The sheeting was cut out to closely outline the LightScribe disc to avoid interfering with the disc drive. Additionally, a large ring was cut from the center to ensure that the LightScribe ID remained uncovered and the drive would function properly.

After the sheeting had been attached to a disc with spray glue, a micropipette was used to evenly distribute the graphite oxide suspension along the burnable area of the disc. Each disc was allowed to dry for approximately three days. In our attempts to reduce graphite oxide to graphene, we experimented with different concentrations of graphite oxide, different distributions of the suspension across the disc and different numbers of burn cycles.

The first discs we ran through the drive did not yield any graphene (at least visually). We attributed our failure to mistakes made in the production of the graphite oxide and to the weakness of our LightScribe disc-drive. We chose to experiment with a more powerful light-scribe system, a tower drive. Since the experiment is time-sensitive, we also decided to purchase a professionally synthesized graphite oxide (75mL) solution to use on our LightScribe discs.

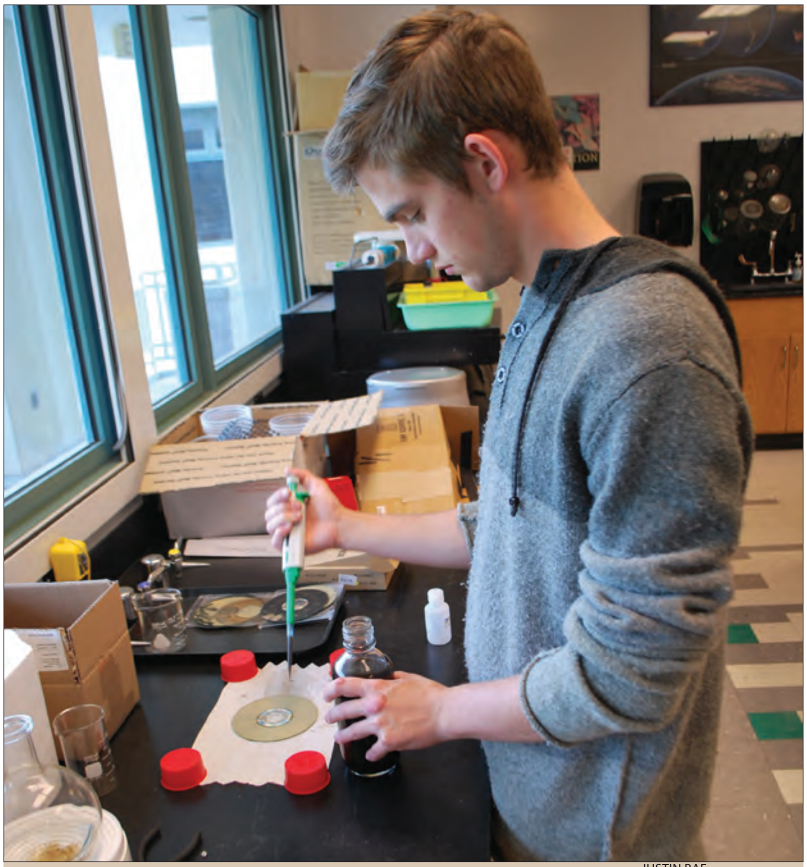
With the installment of the tower drive, the LightScribe burning process began to yield more encouraging results from both the graphite oxide we had synthesized and the graphite oxide we had purchased. First we tested a disc that was coated with the graphite oxide solution we had synthesized earlier. The majority of the area of the disc remained unchanged; however, we noticed some distinct dark spots and circumferential lines that suggested we had produced small amounts of graphene.

Compared to the initial trials we ran with the external drive, the discs were significantly lighter. The second disc run in the tower was coated with the purchased solution, which ultimately yielded better, yet still spotty, results. We surmised that the concentration was too low. Therefore, we increased the concentration by boiling the remaining purchased solution, thereby reducing its volume. The third disc was then coated with the more highly concentrated solution of graphite oxide and run in the tower disc drive for two cycles. The results of the third were significantly better than those of any of our previous attempts.



MAC COLQUHOUN

Fig. 2: Four discs that have been run through the LightScribe drive



JUSTIN BAE

Andrew Friedman '14 works on his research project in the lab.

REFERENCES

Anthony, Sebastian. "ExtremeTech." ExtremeTech. N.p., 19 Mar. 2012. Web. 25 Oct. 2013.

"Carbon Wonderland: Scientific American." Carbon Wonderland: Scientific American. N.p., n.d. Web. 24 Oct. 2013.

El-Kady, Maher F., Richard B. Kaner, Sergey Dubin, and Veronica Strong. "Laser Scribing of High-Performance and Flexible Graphene-Based Electrochemical Capacitors." Science 335.6074 (2012): 1326-330. Print.

"Graphene Micro-supercapacitors to Replace Batteries for Microelectronics Devices." Kurzweil. N.p., 27 Feb. 2013. Web. 24 Oct. 2013.

Hummers, William S., Jr., and Richard E. Offeman. "Preparation of Graphitic Oxide." Journal of the American Chemical Society 80.6 (1958): 1339. Print.

Ling Sun and Bunshi Fugetsu. "Massive production of graphene oxide from expanded graphite." pages 1–2, January 2014.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Designing a Remote Control Plane using Aerodynamics

BY TIGIST MENKIR

The objective of this project is to understand and apply fundamental principles and theorems of aerodynamics, in building a small-scale Remote Control plane, of the Michigan Flyers MX-2 kit model, and creating several airplane designs using NASA's OpenVSP system, a software which enables users to design fuselages, wings and other parts of airplanes in maximizing the structural efficiency of the aircraft.

Bernoulli's theorem describes many of the important properties of airplane flight. The equation, in its most simple form, states:

(static) pressure + 1/2 pV²= (dynamic) pressure

It can be deduced from this relationship, that the pressure of the airflow is inversely related its velocity, and that as air travels a longer distance above the airfoil than below it (and correspondingly must travel at a faster velocity to reach the other end of the airfoil at the same time as the air from below), a lower pressure is maintained above the airfoil than below it, thereby causing lift.

OPEN VSP

After working with NASA's aircraft designing software Open VSP to develop different designs for a full body aircraft, I learned more about designing thinner pods and fuselages, and manipulating scale quantities and combining these designs with the other main parts of the aircraft, such as the body.

The plane structures have thin pod shapes and have almost equal fine ratios of close to 25. One has sweeping wings, with a span length of about 8, while the other possesses wings which are much less triangular in shape, with a span length of abut 16.

CONSTRUCTING THE RC PLANE AND INSTALLING THE ELECTRONICS

After gluing in all the essential body and wing components, the primary structural pieces, or the carbon fiber spars, for the plane were cut, to designated measurements and glued along the plane.

TIGIST MENKIR

Fig. 1: The painted plane in its completion

The first stage of the electronics installation process was the plug-socket connection and consisted of soldering the appropriate plugs to the corresponding sockets in the motor and the ESC (speed controllers).

The second and third stages consisted of increasing the length of the hook-shaped motor mount for easier insertion of the motor and of preparing the servos, which entailed screwing the aileron differential horns into the servo arms. The control rods were then prepared to later be hooked into their corresponding control horns.

The control rods were prepared using the heat shrink method by gluing a smaller rod and a smaller rod with a hook on opposite sides of four long and short spar pieces (after stringing in three wood pieces to the centers of the spar pieces).

Afterwards, the balance of the propeller was verified by use of a balance device, noting if the propeller could orient itself to a steady position.

If not, small pieces of tape were added to either side of the propeller to achieve the necessary balance, and then the propeller was attached to the motor. The servos were then placed in their prepared compartments in the front area of the plane, near the cowl. Afterwards, the 2-cell battery was attached to a velcro strap on the plane, and the battery was connected to the rest of the electronic system.

To allow for easier and more manageable flying with the plane, a gyro was installed.

COLLECTING DATA DURING FLIGHT

In order to compare the effectiveness of different wing types and sizes*, the RC plane was flown with each construction and the time of flight was measured. In order to get quantitatively appropriate results for this experiment, a GPS data logger was attached to the plane to measure the flight distance. The time was also correspondingly measured (by use of a stopwatch) during the flights. The temperature was also measured to account for any unexpected fluctuations in the plane's behavior.

*the wing extensions were mounted on to the wings with the use of popsicle sticks of negligent mass

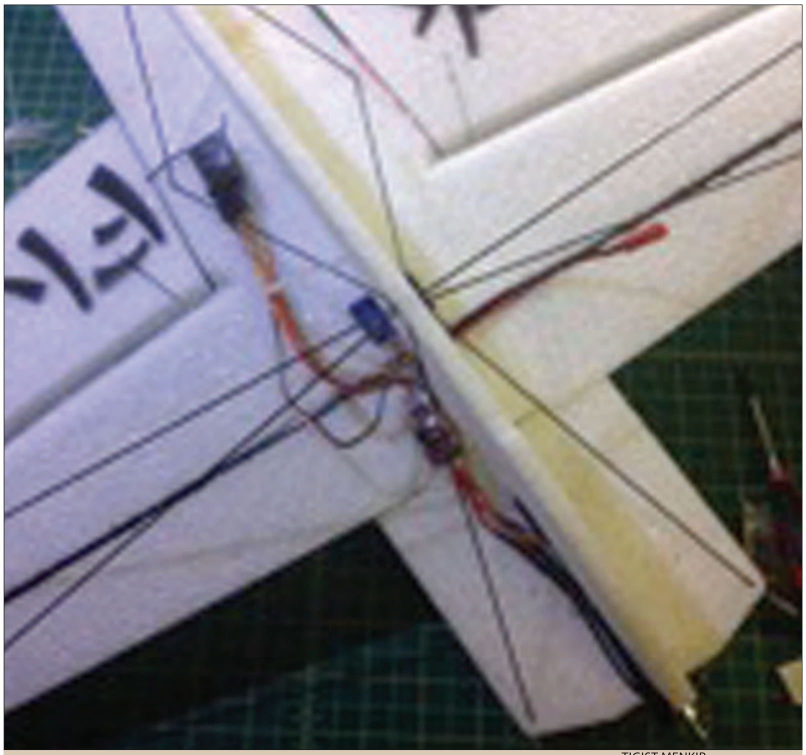
*dimples were created by quartering small Styrofoam balls and gluing them along the surface of the wing

From the data and results obtained, it can be concluded that that the best wing formula for this RC plane, in other words, the wing formation which produced the fastest speed for the plane, was that which consisted of the 22.487g and 19.720g lead weights to the fuselage of the plane. This can be explained by the fact that these weights just added more balance to the plane.

It can also be concluded that the plane with the 5.7in wing extensions on both the left and right wing was very ineffective (slowest air speed). This can be explained by the established principle that longer wings, with their added load weight to the plane, reduce the lift of the body and hinder it from maintaining streamlined and consistent flight.

However, the plane with the dimples, which was expected to fly at a relatively fast speed due to the dimples capability to reduce drag for the wings flew at almost the slowest speed of all the tests. This can be justified by the fact that the dimples, instead of being curved into the wings were protruding hemispheres on the wings, thus counteractively producing even more drag.

In summary, the best wing type for this MX-2 model is a short one with lead weights not exceeding approximately 43g distributed on either wing.



TIGIST MENKIR

Fig. 2: A top view of the plane with a focus on its main electronics.

SOURCES

Text Sources:

Smith, H.C. "Skip". 1991. An Illustrated Guide to Aerodynamics, 2nd edition. McGraw-Hill Professional, U.S.A., 337.
Hewitt, Paul G. 1993. Conceptual Physics, 7th edition. HarperCollins College Publishers, U.S.A., 733.
Anderson, David F. Eberhardt, Scott. 2001. Understanding Flight, 1st edition. McGraw-Hill Professional, U.S.A., 320.

Web Sources:
http://www.wmparkflyers.com
http://io9.com/5606110/why-golf-balls-have-dimples
http://www.wmparkflyers.com/WMPF%20Foamy%20Build-6.pdf

People Sources:
Credits to Mr. Bryan Blaser for providing guidance and advice in regards to the construction of the plane and the flying of the plane during measurements

Thanks to Dr. Nassar for helping me with my project, describing certain aerodynamic principles, such as Bernouilli's theorem, which I was initially baffled by and for encouraging me to be curious, motivated, and enthusiastic to tinker.

Thank you also to Harvard-Westlake for providing the resources to be able to fund an integral part of the project.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Harvard-Westlake's Institutional Review Board

BY JUSTIN BAE

GENERAL IRB INFORMATION AND FORMATION:

The Institutional Review Board (IRB) is a specialized committee that compares the risks and benefits of biological research involving humans. It has the power to approve, require modifications in, or reject proposals, based on if they meet "scientific" and "ethical" standards. To be "scientific," the experiment must have enough benefits to outweigh the risks and use appropriate science procedures and materials. To be "ethical," it must also follow steps to maximize test subjects' welfare and promote fully informed, voluntary participation.

IRBs in commercial organizations, academic institutions and medical institutions all follow the same federal regulations: the group must consist of at least five members; members must be diverse in gender and academic experience to make informed decisions; the IRB must include at least one "Community Member," a person not affiliated with the institution; and members cannot vote on their own projects.

HARVARD-WESTLAKE'S GENERAL IRB INFORMATION:

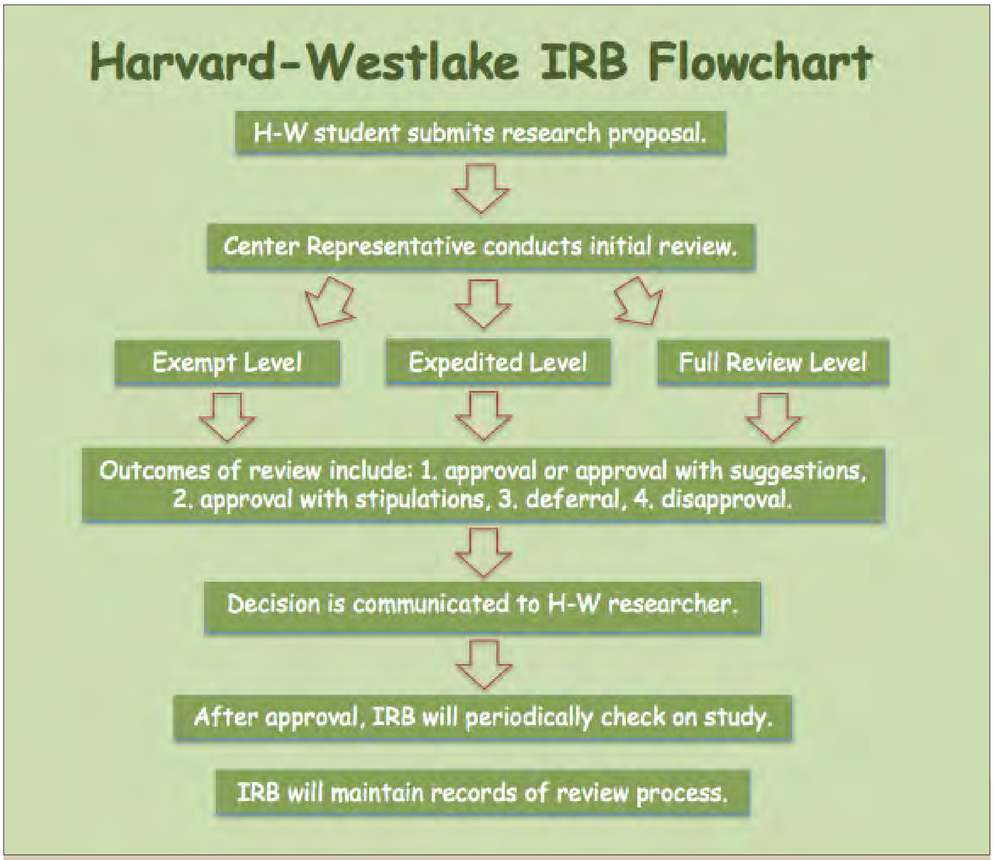
At Harvard-Westlake School, the IRB will be customized for high school students: the time to approve or adjust project proposals is minimized; the review process balances thorough safety regulation and simplicity; and the review board agrees with the school's standards for safety and ethics. Although it will encourage students to conduct their own research, the IRB will enforce responsible investigation methods that minimize safety risks to human subjects, ensure that the anticipated benefits always outweigh the risks, obtain informed consent from participants and continually monitor subject welfare. Failure to fulfill these conditions will result in significant modification of the original proposal or rejection, if the student persists in irresponsible research methods.

HARVARD-WESTLAKE'S IRB FORMATION:

The members of the IRB can vary with the proposal's discipline of science but must be carefully selected. No one connected to the research project, including the principal investigator, an investor with financial interest in the end product, or a blood-relative of the researcher, may sit on the committee. Even in the case that a member must be absent from the meeting, only a formally appointed substitute, pre-determined by the other IRB members, can take his or her place. The board must consist of at least five people and include both researchers and people with little or no scientific training, for a diversity of perspectives and balanced view of the proposed experiment. Community leaders, lawyers and ethicists are examples of eligible non-scientist members, whose primary concerns should solely lie in non-scientific areas. All members are expected to prepare for meetings by reviewing any provided materials and to actively discuss the scientific and ethical considerations of the proposal.

HARVARD-WESTLAKE'S IRB REVIEW PROCESS:

Before submission, a research proposal must include the following: protocols approved by the principal investigator, a sample consent form for test subjects, a list of all data collection instruments and any advertising materials used to recruit test subjects. After submission, a Center Representative will evaluate the proposal with criteria concerning health risks, test subject population information and degree of privacy for subjects' personal data. Based on its calculated risk, the proposal will be passed onto one of two pathways in the Review category: Expedited Level or Full Review Level. The researcher is then notified of the proposal's pathway, the time of the meeting and the review board's conclusions. The possible outcomes of IRB review include: complete approval, which allows the researcher to begin the experiment with suggestions from board members; approval with



JUSTIN BAE

Fig. 1: A proposal can travel through three different routes within Harvard-Westlake's IRB.

stipulations, which permits the researcher to begin under a strict set of conditions; deferral, which contains steps necessary for proceeding to approval; and rejection, which is infrequent but indicates that the study carries overwhelming risks. Even after the proposal is approved, the same panel of members will periodically check on the study with research self-assessments, on-site interviews, and evaluations of lab results. Any substantial changes in the experiment and the completion of the study must be reported to the board.

The Expedited Level committee reviews any research that carries a certain level of health risk or requires parent approval for minors. Eligible projects include interviews with children; collection of blood samples smaller than 50 mL in an 8-week period; non-invasive collection of hair, nail clippings and bodily secretions; and non-invasive procedures regularly employed in clinical practices. The non-invasive procedures can range from moderate exercise and muscular strength tests to flexibility tests and body fat measurements, but they exclude X-ray imaging, tests with microwaves, and strenuous tests on pregnant women.

Full Review Level review is reserved for studies that pose substantial health or privacy risks that exceed those of Expedited Level review. These proposals can involve the administration of drugs to test subjects; physically intrusive procedures; tests on pregnant women or her fetus in utero; protocols that were previously shown to create significant health risks; collection of very personal information on test subjects; and experiments that involve special populations like prisoners and mental disabled patients. Because Harvard-Westlake students do not have the expertise to run such high-risk procedures, the Full Review Level will be reserved for faculty members who have demonstrated sufficient research experience in their prospective fields.

Certain classroom demonstrations and activities may qualify for exemption from IRB review, as part of the Exempt category. Any protocols that have been in use for more than two years are left to the course instructor's discretion and can bypass the process with teacher approval. These include demonstrations with strobe lights, which can trigger epileptic seizures; DNA amplification lab protocols, which swab students' inner cheeks for cells; and anonymous class surveys, which disclose limited amounts of personal information regarding class performance or improvement of the course. Activities that do not qualify for the Exempt category fall under the Review category and must follow the previously defined steps to approval. These include protocols that present a conflict of interest, in which an investigator performs experiments on a research subject; activities that require parental permission; and outside organizations' proposals that were not previously evaluated by an established IRB. The possible pathways within Harvard-Westlake's IRB are summarized in Figure 1.

REFERENCES

"IRB Organization." U.S. Food and Drug Administration. <http://www.fda.gov/regulatoryinformation/guidances/ucm126420.htm#IRBProcedures>.

"Institutional Review Board for Research with Human Subjects: Initial Review." NOVA Southeastern University. <http://www.nova.edu/irb/process.html>.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Such Synchrony, in Reality

BY DONHEM BROWN

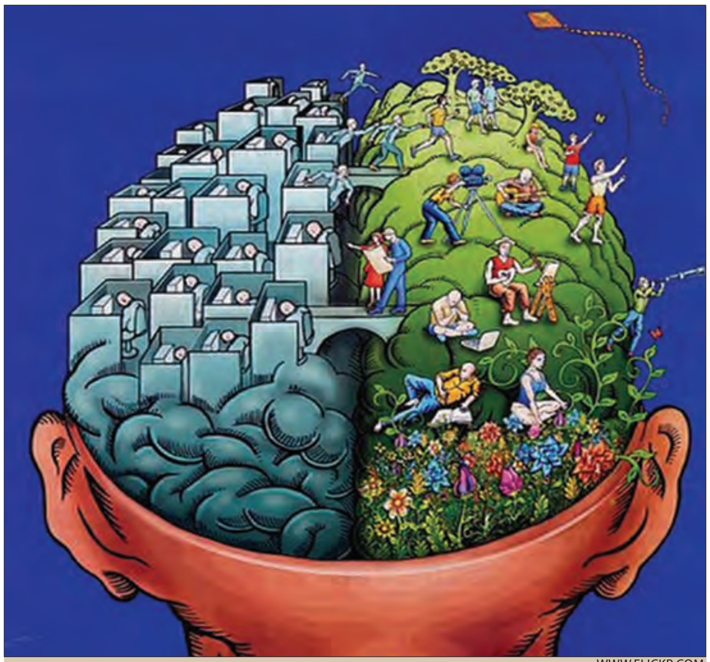
INTRODUCTION

"Who am I?" This is a question that is asked by every human (and perhaps dolphins and elephants?) at some point during their lifetime, and is always amazingly difficult, if at all possible, to find a satisfying answer to.

Although some of us may believe that we have a fair sense of what we should consider constituents of our identity — a combination of the thoughts we typically think, the activities in which we commonly partake, the relationships we form with others, etc. — the concept of a concrete identity, one that is consistent throughout time, seems to hinge mostly on the mysterious nature of "consciousness," and therefore we actually know very little about what truly constitutes our "static identity."

Confused about to what I am referring? I shall clarify. Most of us almost certainly would feel comfortable considering our identities to be some kind of a union between our body and our mind, but this is fairly odd because when one acknowledges that both our bodies and many of the neuronal connections in our brains constantly change over time, we would necessarily be suggesting that our identities are indelibly changing, which is fairly contradictory to the concept of identity.

At the same time, we would certainly feel it silly to not acknowledge that the brain and the body are definitely fair components of our identities, the body being somewhat significant, and the brain being quintessential. This recognition effectuates my belief that identity exists in a dual form: static and variable. This idea is somewhat related to the idea of "nature and nurture:" who one is, and how one "manifests themselves." We are all familiar with the different ways in which one can manifest their actions and opinions, we make judgments and conclusions about their characters based off of observing these manifestations of "activity," but in addition to the potential for variability of character that is derived from the external environment, I believe there is an original construct of identity that persists in each person, regardless of life events, and that this may be able to be determined by "taking an average of the variability that one experiences (what that particularly means will be explored later)."



WWW.FLICKR.COM

Fig. 1: An illustration highlights the current scientific belief about the different functions of the right and left hemispheres of the brain.

I think this static part of identity, "the true identity," is completely correlated with consciousness, and therefore can only be truly understood once the nature of consciousness is understood.

In order to be able to understand the nature of consciousness, we must first deeply analyze and profoundly understand the brain. The brain, responsible for our acknowledgement of our consciousness and our perception of reality, is easily arguable to be the most significant organ possessed by a human being. Without brains as advanced as those found in the human species, the technological, cultural and societal advances we have made would simply not have been possible. This is greatly why it is unfortunate that we know so little about the brain.

PURPOSE

The purpose of the project that I am working on is to help better understand the mechanisms that govern how the brain functions. The specific aspect of the brain that I am focusing on is the synchronization of neuronal activity. Memory, information processing and common bodily functions all seem to be at least somewhat governed by the mechanisms of this aspect.

METHOD

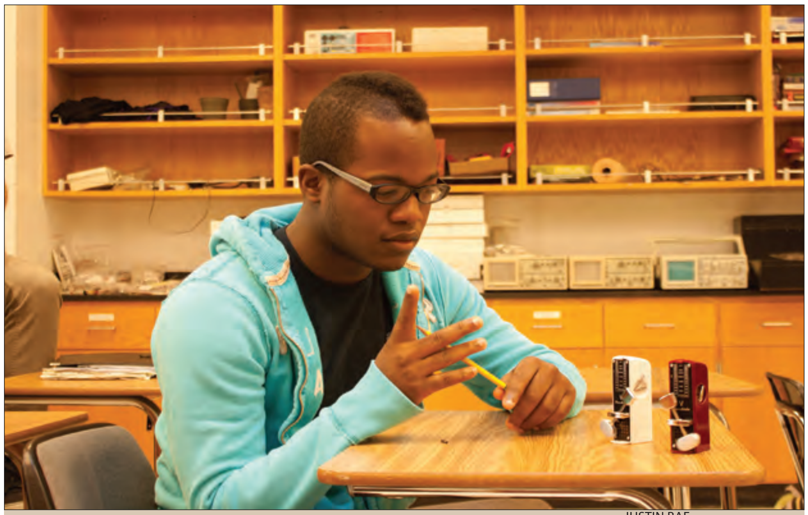
The natural phenomenon of the synchronization of the firing of neurons in the brain is very similar to the synchronization of metronomes. This being the case, I had chosen to first attempt to synchronize several metronomes and to determine under what conditions this would typically occur.

CONCLUSION

The conditions for synchronization that I determined were the metronomes operating at similar frequencies, with a bridge allowing them to share kinetic energy. On an unrelated occasion, I happened to see footage of two hearts connected by a neuron beating in perfect synchrony, and as soon as the connecting neuron was cut, the two hearts started beating completely independently of each other, while each still maintaining the same pace. Events as such allow me to conclude that the potential for two objects to operate in synchrony depends upon both the mechanisms under which the objects operate, which may be unknown, and a means of allowing the objects to exchange "data," whether it is physical or chemical.

In the case of neurons, the chemical neurotransmitters are exchanged between connected neurons, slowing down or speeding up the complementary neurons as needed until all of the neurons in question are operating in synchrony. The necessity of neurons operating in synchrony makes sense, because a lot of human mental processes are reliant on "reinforcement" of a signal, and neuronal synchronization allows for said amplification of signals.

In nature, it is very common to observe synchrony and coupled oscillation. In addition to neurons firing in synchrony, one can also observe fireflies flashing in synchrony, birds flying in synchrony, and the already mentioned rare-sighting of hearts beating in synchrony. The image below is beautiful, and the metaphors that all of these images (some not shown in this article due to copyrights) possess are magnificent. In my mind, there is no doubt that there exists an "oneness" in nature, and evidently our minds and bodies are part of it.



JUSTIN BAE

As part of his ongoing Studies in Scientific Research project, **Donhem Brown '14** attempts to analyze the synchrony of two metronomes.

REFERENCES

Synchronous Rhythmic Flashing of Fireflies. II.
Author(s): John Buck
Source: The Quarterly Review of Biology, Vol. 63, No. 3 (Sep., 1988), pp. 265-289
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/2830425 .

The Luminous World of John and Elisabeth Buck Oxford Journals>Life Sciences> Integrative and Comparative Biology Volume 44, Issue 3 Pp. 197-202

Synchronous Rhythmic Flashing Of Fireflies Science Frontiers

Online:

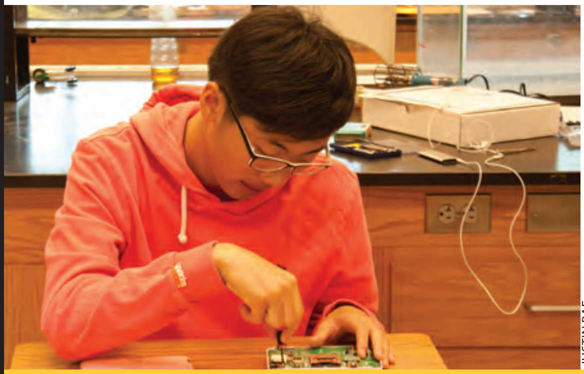
No. 61: Jan-Feb 1989
4. Coupled Oscillators and Biological Synchronization by Steven H. Strogatz and Ian Stewart
Scientific America
http://www.math.oregonstate.edu/~gibsonn/Teaching/MTH323-001S09/Supplements/coupled.pdf

Images:

https://www.flickr.com/photos/tza/3214197147/in/photolist-5U2AQc-5WvJdr-61eaPC-63FBVR-64zrPn-68xLrq-6d7PRx-6etgqr-6mpNCs-6uxhny-6AhRA7-6EN4jw-6SCgsW-6YWkJC-71ACYF-74usom-7b8n7c-7biuSW-7kFnkd-7ue1Vm-7vewvn-815VWu-815VLA-9uTTv6-dwsnUx-8dnMuZ-cmWFEQ-iAHDgN-8gS9ym-a6hY6U-cQV2DJ-a6f7UR-bBZBFE-9MKjen-7Qh26L-ddYGQw-9QU5CM-dXGn5p-i5ChyJ-9qWBHj-iKkeQs-8NQJPe-aTtVqc-8TtRNw-eUH1Dq-cQVrRq-apHoZ5-7V5mkP-bPbME2-dmktpf-ff7ZuD/ the image of the brain used originated from the preceding source; no changes were made to the image.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Automated Shiny Pokemon Machine



JUSTIN BAE

BY WILLIAM LEE

AUTOMATED POKEMON MACHINE

Automation has become a vital part of human society and will only continue to expand in all our lives. The processes make the use of machinery to make tedious tasks efficient by minimizing manual human control. In fact, a lot of systems have become completely automatic. As society continues to develop and integrate such devices to improve the quality of life of its citizens, devices will improve in consistency and usefulness.

Although Pokémon may not be considered the optimal environment to learn robotics, the game provides a simple system for beginner machinery. As the motto of Pokémon is "Gotta Catch 'Em All." I will be doing just that.

SHINY POKEMON

With the release of Pokémon Gold and Silver, Nintendo introduced a rare coloration for certain Pokémon formally referred to as "Shiny."

Upon meeting Pokémon in the wild and in battle, Pokémon have certain set probabilities based on the version of the game to have an alternate coloring. In Generation II with the first release of Shinies, the chances were based on the Individual Values of the Pokémon calculated to be 1/8912. Individual Values are the innate power levels of a Pokémon that range from 0-31 in each health, attack, special attack, defense, special defense and speed stat and are determined by sheer probability as well. IV's can be equated to a Pokémon's genes, and in partner with a Pokémon's Effort Values, base stat calculations can be made.

This method was overhauled by Generation III, and the Shiny rate was now based on the trainer's ID number. However, the odds of finding a shiny Pokémon remained at 1/8912 (8/65536).

In the most recent Pokémon X and Y versions, the standard shiny capture rate has been doubled and now sits at a value of 1/4096. In addition, new methods of catching Pokémon that increase the probability of encountering a shiny Pokémon have been introduced into the game, and will be the bases of my experiments.

INCREASED CATCH RATES

The first method is the Masuda Method, which requires breeding between a foreign Pokémon with a native Pokémon. Though it may seem farfetched, trading with a foreign player from Japan or any other country is necessary for the Masuda method to work properly. The resulting child from the breeding will have an increased shiny rate by six times the standard probability at a value of 1/1365. However, in the newest Pokémon X and Y video game, the specific Masuda Method rate increase is unknown and must be experimented on.

The second method is through chain fishing. By fishing in the same location repeatedly, the likelihood of encountering a shiny increases by an unknown value. However, the catch, no pun intended, is that the chain must be uninterrupted, hence the chain in the name. This means that the human player must respond to the sight or sound of a Pokémon biting the line without fail every time. Failing to do so will result in an unsuccessful chain, and the shiny catch rate will reset. Because humans cannot perfectly react, mistakes will be made, and automation can ease the load on the human player. To determine the rate at which Shiny Pokémon appear with an increased chain, perfect data will be necessary in order to save time, and an automatic system will prove the most effective.

The third method is less of a process, and much more simple. By completing the national Pokédex, trainers are rewarded with a Shiny charm, which increases the Shiny rate of Pokémon in the wild by an unknown value. Furthermore, it is unknown whether this item compounds with the other methods of increasing the Shiny rate, so will be left out of the data collection. The last is a painstaking process known as just chaining, which is different from chain fishing, and much more complicated. With my current capabilities and limited resources, I will be unable to reproduce the necessary patterns through machinery. Regardless, I will briefly explain this method. Using the Pokéradar, which is received after completing the specific regional Pokédex, stand in a patch of grass at least of size 4x4 and observe the patches of grass shake. By stepping into the most violent grass, in a chain similar to the fishing, you will increase your chances of finding a shiny Pokémon. However, the vibrations are very slight, and the process has many kinks that make a feasible automated device near impossible.

EXPERIMENT

Due to the currently unknown rates of Shiny encountering, I devised a device to help automate the process of data collection in order to form specific conclusions. I decided to focus on the first two methods mentioned, the Masuda method and chain fishing, for simplicity's sake. The largest difficulty for the task was designing a simple and efficient machine to perform the necessary tasks. In order to breed Pokémon, the avatar must visit the Day Care and leave two compatible Pokémon to mate. The player must then walk 255 steps, and the game will decide whether an egg has been created based on the compatibility between the two Pokémon. The device must take into account that an egg may not be hatched every 255 steps, so the player must ask the Day Care employee after each iteration. The maximum party size is six, so after five eggs are received. The avatar must then walk a certain number of steps until all the eggs are hatched. Afterwards, the offspring will be deposited into the PC, and the task will be repeated. After a large sample of Pokémon have been breeded, I will be able to calculate the percentage of Shiny Pokemon in comparison to standard Pokémon hatched and obtain the desired rate.

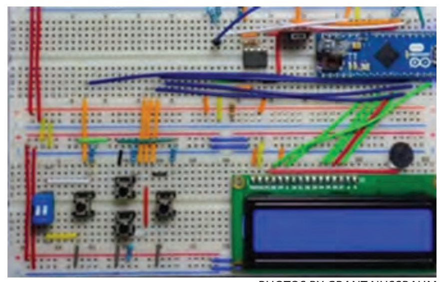
For chain fishing, I had to think of a way to determine whether the player encounters a Shiny Pokémon on the line to not interrupt the chain, and then proceed to catch said Pokémon. I will use a sound sensor to hear the exclamation when a Pokémon bites the line to trigger the device to begin the process to reel in the Pokémon. In addition, I learned that the bottom half of the screen stays black for a longer period of time when a Shiny Pokémon is reeled in than when a standard Pokémon appears. Because of this, a light sensor can be attached to the screen and measure the time interval of the black screen, and if it exceeds a certain number, the device will know to execute the catch Pokémon command. By catching Shiny Pokémon through fishing, I will be able to calculate a general trend on the average Chain length to catch a Shiny Pokémon.

APPARATUS

I will use two microcontrollers for my Shiny Pokémon catcher. The Arduino Uno will be the master, handling the load of the work, while a Teensy will support the main unit. In order for the Arduino to control a physical 3DS XL, I must use mounted solenoids to press the buttons on the device. Instead of soldering wires directly to the buttons, I would like the Pokémon catcher to work on all devices with minimum interior tampering.

For the sound and light sensor, I will be using standard devices found in many beginner electric engineering packs. In order to project words to the human operator, I will use an LCD screen. The screen will be able to output what commands are being processed as well as keep track of the fishing chain or number of Pokémon eggs hatched.

◄ Nintendo 3DS XL



Arduino Uno ►

PHOTOS BY GRANT NUSSBAUM

Attached to the breadboard, I will have a set of buttons that will allow me to control the input to the Arduino. A set of four will suffice as an up-down-left-right pad. I must also have another switch to activate or end the process. The last major part of the machine will be an SD card in order to save data retrieved from Pokemon breeding and catching.

The electronics will be constructed over two breadboards incorporating all the devices listed above. However, I must set up the integrated circuits, wire jumpers and remaining electronics for the device to work appropriately. The end result will look similar to the setup below. The next hurdle will be the actual programming of the Arduino and Teensy to perform the processes delineated above.

CONCLUSION

The idea of a Pokémon Shiny Catcher may seem ridiculously childish, but in reality, is a huge stepping-stone for me to learn engineering. As evident, the process of actually Shiny Pokémon is an intricate process, and the automation will ease the load on a human player in acquiring rare Pokémon. Furthermore, the skills learned through creating this device can be applied to future robotics and engineering projects.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Investigating the Properties of a Rail Gun

BY OJAS PARASHAR

ABSTRACT

Ever since the discovery of the relationship between electricity and magnetism, magnets have been used for various things. Most relevant to this paper is their use in Linear Particle Accelerators. Though the Linear Magnetic Accelerator or Rail Gun is only very distantly related to Particle Accelerators, the basic premise is the same. This paper is written with the intent of exploring the effects of changing various variables in a Linear Magnetic Accelerator.

DESIGN OF A LINEAR MAGNETIC ACCELERATOR

The design of a Linear Magnetic Accelerator, here on referred to as a "Rail Gun" only, can be understood through its name alone. The track that was used in this particular study was 9 feet long and made of aluminum, a metal that is not attracted by magnets. The actual "magnetic acceleration" took place like so.

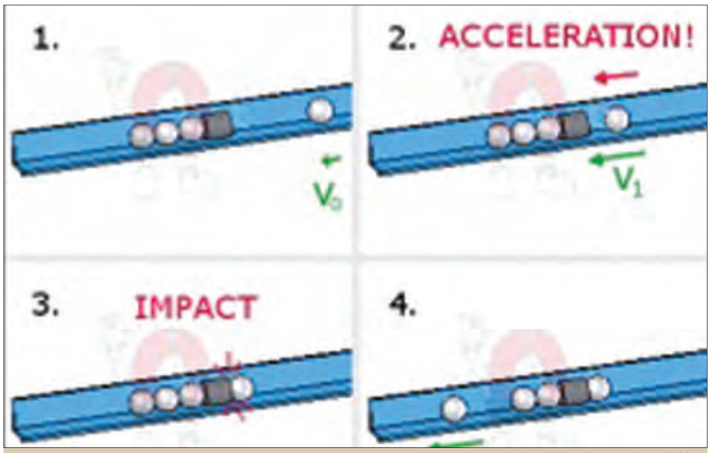


Fig. 1: This four-step process describes the mechanics behind a rail gun. Momentum transfer and acceleration are the key processes.

As is shown in the graphic above, the setup of the accelerating device was a cylindrical magnet with three ball bearings (made of steel). When another ball bearing was launched at with some initial velocity, the magnet would accelerate the ball bearing to a significantly greater velocity and after impact, due to the momentum transfer, the ball bearing farthest from the magnet (on the other side of the approaching ball bearing) would be launched with a velocity away from the "accelerating unit," that is the magnet and the other ball bearings.

However, some initial testing that suggested that using two ball bearings was more efficient in terms of energy and momentum transfer. The effects of three ball bearings will be tested as the experiment progresses. In addition, the graphic shows that a simple, track is used. However, to reduce friction even further by reducing the area of contact, a "U" channel was used.

The final setup looks like so with just three feet of track on display and one accelerating unit.

The technical specifications of everything used are described below:

- Magnets: Rare Earth Metal Neodymium Cylindrical Magnets 1/4" radius and 1/4" height. Grade N48.
- Ball Bearings: 1/4" radius steel (non-magnetic) ball bearings
- Track: 9' Aluminum U Channel Track

EQUATIONS AND OTHER MATHEMATICAL DESCRIPTIONS

The standard expression for the magnetic field exerted by the magnets on the ball bearings that are a distance x away from the edge of the magnet is:

$$H=k/x^2$$

The constant k is different for each magnet based on material of magnet, grade and dimensions. For the particular magnet that I used the equation (derived through testing and an online calculator) was:

$$H=111.3/x^2$$

Where is measured from the edge in inches and H is in Gauss. To find the force exerted by the magnetic field requires knowing the constant of magnetic attraction of the steel ball bearings, which is not known. In addition, finding a reliable method

ANSER ABBAS

Ojas Parashar '14 launches a three stage linear accelerator. This linear accelerator models the particle accelerators at CERN and Fermilab..

to measure the force through experimenting has proven difficult. Further testing will be done on this in order to achieve a satisfactory level of knowledge or to simply deem this data impossible to gather.

MEASURING VELOCITY AND ACTUAL EXPERIMENTING WITH THE RAIL GUN

More experimenting will actually be done to measure the following variables:

- The effects of changing the distance between the magnetic units
- The effects of changing the ball bearings
- The effects of changing the magnets
- The effects of increasing the number of magnetic units
- The effects of changing the number of ball bearings on each magnetic unit

RESULTS, CONCLUSION AND FUTURE

Due to a lack of an accurate and repeatable way to measure the velocity of the ball bearings as they travel, all data gathered is estimated by observing video recordings.

Some general observations are listed:

- At around 2.8cm, the attraction force of the magnet is large enough to attract the ball bearing from rest
- There is a backward movement of the units due to conservation of momentum.
- Velocity does not continue to increase at the same rate, however, at four units of acceleration, the ball bearings travel fast enough to chip and damage the magnets.

The data was rather extensive and has been summarized in this results table:

	1 Unit	2 Units	3 Units
Velocity (m/s)	1.3	2.4	3.0

This was the maximum velocity that was observed. In addition, the ideal distance was measured as follows:

- 15.2cm for 2 units
- 22cm for 3 units

The reason for these ideal numbers is because of the fact that initially the ball bearing is sliding, not rolling, on the aluminum track, which results in very low friction. The distance between the "units" is the distance the ball bearing slides before starting to rotate.

In addition, there was very little difference in the maximum velocity attained between using 2 BBs in the units vs. using 3 BBs in the units. Due to certain restrictions (magnet size and fragility and track width) other ball bearing sizes did not yield high quality data as they often fell off the track or they damaged the magnets. The velocity attained is impressive but by no means dangerous. Pursuing a further analysis of the physics would require mathematics that is unavailable and more equipment that is also unavailable.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Solvated Electron Colloids As A Method For Electric Field Visualization

BY ANSER ABBAS

BACKGROUND

Under certain conditions (primarily ammonia-metal solutions), free electrons can exist in solution and are visible to the naked eye as deep blue particles. These solvated electrons are the smallest possible anions. This experiment will determine whether or not a solution or colloid containing solvated electrons would be a useful means of visualizing the electric field surrounding a circuit element.

USEFUL PROPERTIES OF SOLVATED ELECTRON SOLUTIONS

Electride-metal solutions have many properties that would lend themselves well to the visualization of the electric field due to surface charges on a wire. As discussed by Jacobs, de Salazar and Nassar in 2010, the two existing methods of visualization are Jefimenko's method using conductive ink and grass seeds as an indicator, and their own method that uses PTFE sealant in mineral oil to determine the electric field around a wire passing through.

Solvated electrons are visible in solution as fine particles. Perhaps the most important property of these solution is that varying the electride concentration changes the magnetic properties of the solute: at a certain concentration, electrons begin to couple and the solution changes from paramagnetic to diamagnetic. Thus, the attraction of the solute to the wire could be increased to make the effect more visible or decreased to prevent clumping and make the effect more coherent. Finally, electride-metal solutions are themselves electrically conductive, and could potentially be used to modify Jefimenko's method (replacing grass seeds and ink with electrons in solution).

METHOD

The preparation of electride-metal solutions is well documented. Many solvents can carry solvated electrons; however, the most feasible setup given our resources would be a cooled petri dish of liquid ammonia near -60 degrees Celsius (most likely by a liquid nitrogen setup), with a fragment of sodium metal dissolved within. The new method would also involve running a high-voltage wire through a petri dish of the new solution.

JUSTIN BAE

Anser Abbas '14 prepares the solvated electron solution before cooling.

CONCLUSION

Though somewhat more complicated to design than its predecessor, the solvated electron solution or colloid method could be a useful adaptation and has potential to allow for more fine-tuning of the produced fields. In many ways, this phenomenon is a spectacular demonstration of electrochemistry, and hopefully this experiment will give this curious effect a practical purpose.

SOURCES

Jacobs, de Salazar, Nassar. "New experimental method of visualizing the electric field due to surface charges on circuit elements." American Journal of Physics 78 (2010): 1432-1433. Print.

Source: Universität Heidelberg, http://www.uni-heidelberg.de/md/ipmb/chemie/klein/solvated-electrons.jpg

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Hovercraft

BY SAM CLEMENT

A hovercraft is an amphibious vehicle that is supported by a cushion of slightly pressurized air. Although often seen as a mysterious, even bizarre mode of transportation, it is conceptually quite simple. Hovercrafts float on a cushion of air that has been forced under the craft by a fan.

This causes the craft to rise or lift. To make the craft function more efficiently, it is necessary to limit the cushion air from escaping, so the air is contained by the use of what is called a hovercraft skirt. Most often fashioned from fabric, which allows a deep cushion or clearance of obstacles, hovercraft skirts vary in style ranging from bags to cells to separate fingered sections called segments. Once “lifted” or “on cushion”, thrust must be created to move the hovercraft forward.

With most crafts, a separate engine from the one used to create the lift generates thrust, but with some, the same engine is used for both. As the diagram above indicates, the fan-generated air stream is split so that part of the air is directed under the hull for lift, while most of it is used for thrust. Now that the hovercraft has lift and thrust, it must be steered safely.

The Harvard-Westlake hovercraft is designed by a company called PASCO based in Roseville, CA. A nylon skirt is stretched around a wooden disk and is held in place by a tight strong steel wire. The center of the skirt is attached to the bottom of the wood platform. The nylon skirt is made to fit the circumference of the wood platform.

ANSER ABBAS

Sam Clement ’14 poses with his hovercraft that he designed for SSR.

A bumper stretches along the outside of the nylon skirt to provide protection from sharp objects. A leaf blower is used to push a high volume of air into the skirt to create an air pocket. When the leaf blower is turned on air begins to flow into the skirt. Small holes on the skirt allow the air to escape, while providing the higher pressure needed to lift the rider.

The PASCO hovercraft kit did not come with anything that could generate thrust or any way of steering the craft. Upon first use the hovercraft lacked the lift to reduce friction to the point of becoming irrelevant. My partner, William Lee, and I decided to increase the lift of the hovercraft by drilling another hole in the wooden disk and adding another leaf blower.

We designed an experiment to test for the coefficient of friction of porous concrete and slick linoleum. Pulling the hovercraft along both surfaces at a constant velocity, we measured the force applied when pulling the hovercraft. Because the velocity was constant, the equation F_k = mW is true. After weighing the hovercraft, we could solve for the coefficient friction.

Concrete

Force = 2N

u = 2N / 204.62 = 0.00977

Linoleum

Force = 0.5N

u = 0.5N / 204.62 = 0.00244

Summer Internships

Many students take advantage of research opportunities at local institutions over the summer.

NATHANSON'S

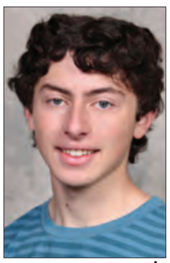
USC's Early Investigator High School Summer Program
Zachary Birnholz '14
"I investigated the effect of the DLK-1 protein on stem cell pluripotency and cancer cell malignancy at Children's Hospital Los Angeles."

NATHANSON'S

UCLA Physics Lab
Nicholas Brooks '14
"This past summer I worked in a UCLA physics lab that dealt with the properties of superfluid helium. We didn't really get much done and I spent a lot of time fixing things."

NATHANSON'S

Seung Labs at Massachusetts Institute of Technology
Donhem Brown '14
"I worked to help map regions of the 'connectome,' particularly those in the retina. The term refers to the collection of all of the neuronal connections in the human body."

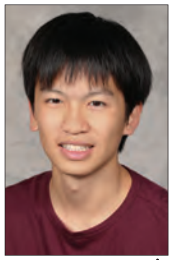


NATHANSON'S

UCLA Smart Grid Energy Research Center
Jonathan Burns '14
"I built an iPhone application that would connect with the Smart Grid systems at UCLA to allow users to control the charging of their electric vehicles."

NATHANSON'S

Moonfrye, Inc
Kelly Crosson '14
"I interned for Moonfrye, Inc a startup family community that operated and created a family photo app and parent blog. Working under Kara Nortman '93, I learned so much about startups and entrepreneurship."



NATHANSON'S

USC School of Pharmacy Genetics Lab
Aaron Shih '15
"Last summer, I worked to a genetics lab at the USC School of Pharmacy and helped with research on the relation between the gene that codes for monoamine oxidase and cancer."

NATHANSON'S

Coastal Marine Biolabs Neurolab
Taleen Mahseredjian '14
"We studied bioluminescence directly through dives off the Channel Islands. We then mapped neural pathways in chick embryos with fluorescent proteins."

NATHANSON'S

Clark Scholars Program at Texas Tech University
Kevin Zhang '14
"I learned to code Javascript and wrote a Mozilla Firefox extension to detect potential security leaks (e.g. phishing) while surfing the Internet."

NATHANSON'S

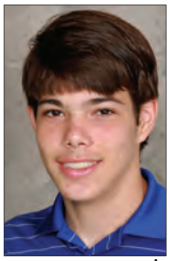
Harvard Stem Cell Lab with Dr. Doug Melton
Lizzy Thomas '14
"I worked in Dr. Doug Melton's stem cell lab at Harvard for two weeks last summer. Dr. Melton and his team are conducting diabetes research."

NATHANSON'S

NextEngine
Brendan Wixen '15
"I worked on new product development at NextEngine (manufacturer of 3-D scanners). My role involved engineering, demonstration of concepts, and testing of electrical components and microchips."

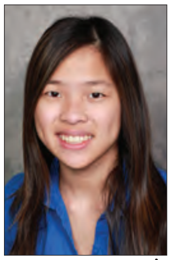
NATHANSON'S

Keck Graduate Institute in Claremont with Dr. Biranchi Patra
Enya Huang '15
"I studied the impact of varying concentrations of butanol in the environment of yeast cells as well as the process of transduction."



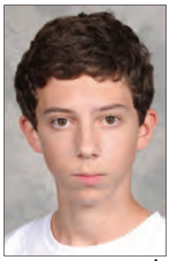
NATHANSON'S

UCLA with Dr. John Olsen and USC with Dr. Wei-Min Shen
Mane Williams '14
"I worked on Drosophila Melanogaster (fruit flies) genetics at UCLA, and also had a robotics internship at USC programming a self-modulating robot in a simulator."



NATHANSON'S

Zilkha Neurogenetic Institute with Dr. Dan Campbell
Irene Kao '14
"I sequenced and analyzed the MET gene in autistic children and their mothers. I used quantitative PCR to determine the effects of the RPS gene on other genes implicated in autism."



NATHANSON'S

Simons Summer Research Program at Stony Brook University with Dr. Bruce Demple
Jonathan Sington '15
"Working in the Pharmacology laboratory under Dr. Bruce Demple, I investigated the ability of mitochondria to repair their damaged DNA."

NATHANSON'S

The Center for Advanced Surgical and Interventional Technology
Sophie Kupiec-Weglinski '15
"I worked at The Center for Advanced Surgical and Interventional Technology. It is a research facility at UCLA where I helped test various surgical robots and learned some coding."

JOURNAL NOTES

From SSR to MIT and beyond

BY IAN CINNAMON '10

It all began with Studies in Scientific Research... I remember taking SSR junior and senior year of high school. I had always been interested in entrepreneurship and wanting to make something of my own, and the opportunity to explore any science-related idea was just too good to pass up. Years later, I remember talking to one of my Massachusetts Institute of Technology professors asking why a top-tier research university couldn't provide a class or program like SSR.

During my time at MIT, I worked in a variety of research labs from cognitive science labs where our research helped teach the United States Army how to better read satellite data to a biology lab where we studied Adderall withdrawal symptoms in mice.

In all of these lab settings, the Principal Investigator asked where I learned so many of my lab skills, and I was happy to credit all of it back to SSR. It's incredible how much one can learn while exploring the ideas and products one cares about most. It's amazing to think the skills and techniques I developed in SSR still apply to this day. Lately, in my role as Director of Strategy of Immunity Project (a nonprofit Y Combinator-backed startup developing an HIV vaccine to distribute to the world, for free), I've used the laboratory skills I learned during SSR while dealing with the live HIV virus.

PRINTED WITH PERMISSION OF IAN CINNAMON

Ian Cinnamon '10 took Studies in Scientific Research as a junior and senior.