HWJS

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Railguns in Aerospace
Constructing a T-Shirt Cannon
Unmanned Aerial Vehicles

JOURNAL NOTES

The relationship between *research* and *playfulness*

NOA YADIDI

Rhett Gentile '13, left, shows off the $25 Raspberry Pi computer to science teacher Antonio Nassar, right, at STEMfest.

BY ANTONIO NASSAR, *SSR TEACHER*

*Google allows its employees to use up to **20 percent** of their work time at Google to pursue their own special projects and to have fun.*

Employees can take a full day per week to work on a project unrelated to their normal workload and to have fun. Google knows that playfulness encourages imagination and the exploration of possibilities, qualities that are necessary in the conduct of a creative environment.

Likewise in science, many eminent scientists are known for their playfulness. Einstein's famous statement that "imagination is more important than knowledge…" and his formula for success indicates the value he placed on playing with ideas. Kary Mullis, recipient of the Nobel Prize for Chemistry claimed: "I think really good science doesn't come from hard work. The striking advances come from people on the fringes, being playful." According to the daughter of Robert Burns Woodward, who won the 1965 Nobel Prize in organic chemistry, his lifetime work was playful, extending "into mature forms of search and research."

Arthur Schawlow, winner of the 1981 Nobel Prize in physics for his work with lasers, said, "I know a little bit about a lot of things and I have a lot of curiosity, and somehow, ideas come… I guess you'd say I like to play. That's true, I like to learn about a subject by getting in and getting my feet wet by trying something, doing some kind of experiment." Few famous scientists have written positively about their school or university science course experience. However, Arthur Schawlow mentioned a memorable university lab where the professor challenged students to investigate the relationship between balloon air pressure and diameter and the depolarization of light. "It was a lot of fun, just turning us loose," he wrote.

Another aspect of pleasure in science research may be social. Students enjoy "making good friends and getting to know fun and interesting people" as well as the physical aspects of exploring science. So, research must be fun and interesting.

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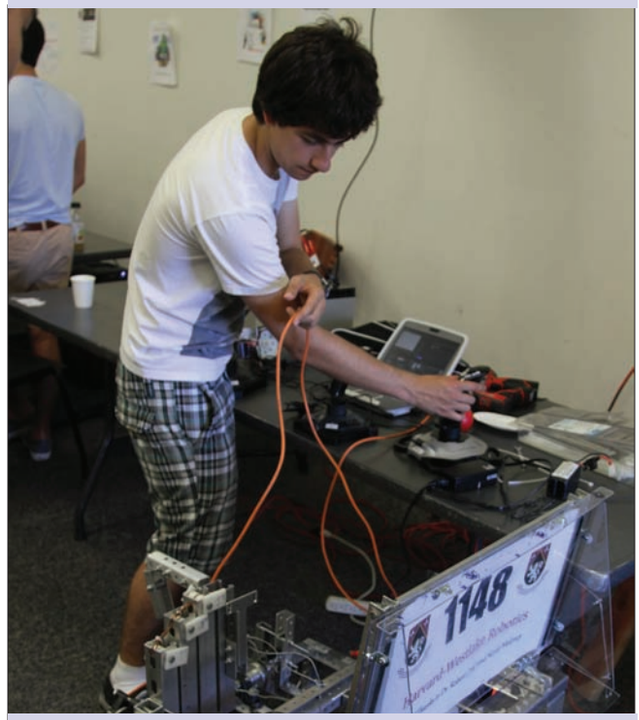
Advisers: Dr. Antonio Nassar and Kathleen Neumeyer

Alex Cadiff '13 makes ice cream for students by freezing the ingredients using liquid nitrogen and mixing.



josh Lappen '13 uses a joystick to demonstrate the robot that Robotics Club sent to a local competition.

JACK GOLDFISHER AND NOA YADIDI

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Creating the Mirage Effect (Photothermal Deflection)

BY **SACHA BEST, ALLEN NIKKA AND CHRIS SEBASTIAN**

Causing the mirage effect via a large temperature differential can be achieved it a variety of ways, two of which are investigated here, resulting in data which is informative as to the difficulty of creating a photon deflecting mirage with both methods tested.

The mirage effect, also known as photothermal deflection, is an observable phenomenon that bends light waves away from the area of its occurrence. Moreover, this occurs because the light waves move more quickly through the hotter, and therefore, less dense part of the medium, and more slowly through the colder part. When the difference between these two temperatures is high enough, this angle of light deflection is readily observable, and produces the mirage effect.

CONCEPTS

The mirage effect has been tested in a variety of ways, but here I will focus on two studies, one by the BYU group[2], and the other by the University of Texas at Dallas group[1]. The BYU group's experiment examined the degree at which the beam of a helium neon laser was bent by the mirage effect. They created the conditions necessary for photothermal deflection using a hotplate and metal pan full of ice water, positioning them ~6mm away from one another and firing the laser between them. The experimental setup of the group at the University of Texas at Dallas consists of running electric current through a carbon nanotube sheet. Due to the properties of multi-walled carbon nanotube sheets (MWNT's), which include causing a drastic heat increase in the surrounding medium when electric current is running through them, positioning them between two electrodes in a medium of choice allowed the Dallas group to cause photothermal deflection.

APPARATUS

Our experiment attempted to achieve the same effect using aspects of both procedures. We did this using high gauge nichrome wiring because of its desirable heating capabilities, with an arrangement similar to that of the Dallas group's experiment. The wire was configured into a mesh checkerboard pattern, with intervening empty spaces. To prevent the formation of a salt bridge, and the further formation of an electrical charge in the water medium, we ensured that we were using, at the least, highly distilled water.

ALLEN NIKKA

FIG. 1: Nichrome wire mesh in beaker carrying electric current.

EXPERIMENT (SHEET SETUP):

We placed the wiring into a water bath, due to water's high refractive index, in this mesh-like tessellation, allowing for the ideal heating of the wiring. We then passed a current through the wire, heating it at a much

more rapid rate than the surrounding liquid medium (which would require approximately 5 amps, 1.7 watts, and 20 volts of electrical energy with our setup) to the point where the heat differential between the wiring and the water was be large enough to cause observable phenomena. Like the BYU group, we also measured the ambient temperature of the water, as well as the water extremely close to the nichrome wiring itself, to determine the degree of temperature difference we created.

SECONDARY EXPERIMENT:

Following this first experiment, we attempted to replicate the BYU group's experiment, with a slightly modified setup. This setup consists of a pan of ice water (which, on the bottom, achieves temperatures of about 45°F) suspended 1 cm above a hot plate that achieves temperatures, on its surface, of above 300°F. This creates a heat differential of over 250°F across a 1 cm large gap that would, ideally, cause a mirage in the same fashion that it was achieved in the BYU group's experiment. This diffraction will be measureable by laser, as a laser can easily be fired through the gap before and after activation of the apparatus, and any diffraction will be apparent in the altered position of the laser.

CONCLUSION:

Sheet Setup:

At this point, our experimental setup has successfully created a visible heat haze, which, due to its being hotter than the surrounding medium, forms in a rising, curtain-like fashion. Technically, this is the achievement of the mirage effect (deflecting photons of light via a temperature differential), however, further goals, such as being able to maintain the effect, as well as modifying the positioning of the apparatus so that the rising haze is not apparent compared the distortion itself, remain current goals of the experiment. Furthermore, comparing these results from those we can achieve by replicating the BYU group's experiment to a certain degree will also help us understand how successful our experiment was.

Secondary Setup:

After setting up and carrying out the second phase of our experiment, as a way to gauge the success of the first version, which we came up with as a modified version of the carbon nanotube sheet version of the experiment detailed above, we received minimal results. Over a three foot gap between the apparatus and the area where the laser's diffraction was being measured, we found no measureable diffraction of the beam, although the temperature differential was measured to be greater than 225°F. This can be due to several factors, to of the most obvious being the distance between the hot and cold planes, which was far greater than the distance between them in the BYU experiment, but could not be improved upon given the materials present. The other was the relatively short distance from which the diffraction was measured, however, continuing trials from greater distances continue to yield no results, suggesting that the increased distance, or some other factor unaccounted for, is causing our lack of a positive result.

FIG. 2: (Above) The secondary hotplate setup in front of the beaker containing the nichrome setup.

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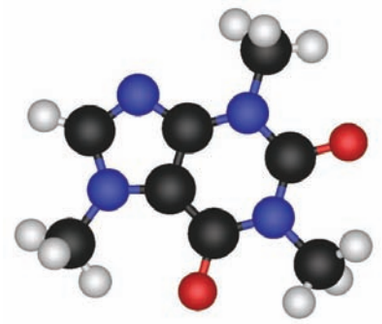
1. http://iopscience.iop.org/0957-4484/22/43/435704

2. Richey, Lauren, Bailey Stewart, and Justin Peatross. "Creating and Analyzing a Mirage." *The Physics Teacher* 44 (2006): 460-64. Print.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Testing the Effects of Caffeine and Coffee on Fruit Flies



BY **PAHELI DESAI-CHOWDHRY**

Many people consume **caffeine** in various forms, including coffee. Caffeine is known to affect sleeping patterns, mental and physical capabilities, and may even cause **genetic mutations**. This experiment tests the effects of caffeine and coffee on **fruit flies.**

Many people worldwide consume caffeine daily in their morning cups of coffee, tea, soft drinks, and chocolate. Caffeine is known to stimulate the nervous system; because of its similarity in molecular structure to adenosine, a neurotransmitter, it attaches to adenosine receptors. While adenosine causes drowsiness, caffeine has the exact opposite effect, sending a flow of adrenaline into the system and putting us into the "fight or flight" phase. Some symptoms include increased blood pressure and heightened alertness. Since fruit flies have similar nervous systems to those of humans, I assumed that the results of testing caffeine on fruit flies would give some insight about the effects of caffeine on humans. Fruit flies reproduce very quickly; therefore, it will also be helpful to observe possible genetic mutations caused by caffeine. They have been used in previous research projects about genetics.

Data Table 1

Culture:	Trial 1 Time (seconds)	Trial 2 Time (seconds)	Trial 3 Time (seconds)
Control C	13	8	9
Coffee B	10	11	6
Caffeine A	11	13	8

Data Table 2

Culture:	Trial 1 Time (seconds)	Trial 2 Time (seconds)
Control C	11	8
Coffee B	9	6
Caffeine A	15	14

Data Table 3

Amount of caffeine (mL)	2.5	5.0	15.0
Days until death	8	6	6

I ordered three separate fruit fly cultures. In order to create a fruit fly culture, there are a few necessary ingredients: sugar, protein, vitamin, yeast, and moisture. Before transferring them from their shipping containers to their culture containers, I mixed pure caffeine power in the food in one culture container (Jar A) and Starbucks black coffee (representing a widespread type of coffee consumed by humans) in the food in a second culture container (Jar B). I did not mix anything in the third culture (Jar C) container, as it serves as a control group so that I can observe the differences between fruit flies under the influence of caffeine and normal fruit flies.

In the first few days, there was no observable difference between the three cultures. On the fourth day, to test the possible effects of the caffeine and coffee, I tracked the progress of a couple of flies in each culture to see how long it took for them to climb from the bottom of the container to the lid. My results were as follows (see data table 1).

As you can tell, there was not too much difference between the times of the two cultures. However, two days later, the same experiment yielded different results: (see data table 2).

The flies in the caffeine culture A were significantly slower than the others and they seem more jittery – less coordinated and stable relative to the flies in the other cultures.

A week later, most of the flies in the caffeine powder jar (Jar A) were dead. The anhydrous caffeine powder is the purest form of caffeine and contains much more caffeine than the Starbucks Black Coffee.

In the control and coffee jar (Jars C and B respectively), there were little black dots crawling in the food media, which I assumed to be offspring of the flies. In the control jar, there were even larger white larvae. There were a few white larvae in the coffee jar but they were significantly smaller.

This observation could suggest one of two possibilities:

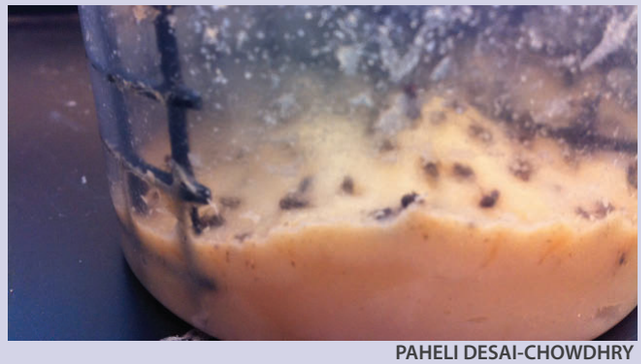
1. The coffee stunts the growth in the offspring of the flies

2. The coffee causes the flies to mate less frequently.

My research in various books and online sources suggests that caffeine does not directly stunt the growth of fruit flies. However, caffeine does affect sleep, which is especially important for children or developing offspring, for whom more sleep is required. First, caffeine makes it more difficult to fall asleep. Then, it causes awakening and decreased the amount of deep sleep, during which important growth hormones must be released into the body. Sleep is restorative and good for storing energy, and this benefit is lessened by the effects of caffeine. Caffeine has been known to increase the risk of miscarriage for pregnant women and has shown birth defects in rodents in similar studies.

To experiment further, I started breeding fruit fly cultures with varying concentrations of caffeine in order to determine the amounts of caffeine that make it lethal (see data table 3).

There were four fruit fly cultures: one control group and three with varying amounts of caffeine as follows:



PAHELI DESAI-CHOWDHRY

Coffee Culture Jar

2.5 mL, 5.0 mL, and 15.0 mL. 6 days after setting up the cultures, I found that the flies in the 5 mL and 15 mL cultures were dead, and 2 days after that, the flies in the 2.5 mL culture were dead as well.

When I was experimenting with the anhydrous caffeine powder that I ordered from Amazon to test on the flies, I made an interesting discovery. I wanted to see if I could make caffeine crystals, so I dissolved as much caffeine powder as possible in warm tap water and then let the water cool. Then, I left the caffeine and water solution for a few nights and allowed the water to evaporate. The result was the formation of long fiber-like crystals (pictured below).

This might be relevant because it might possibly form these fibers when it is ingested, since the body is mostly composed of water. The fibers could be potentially hazardous and even life-threatening because they might block passageways in the body. The caffeine crystals could possibly explain why the caffeine powder fruit flies perished so quickly, and why large amounts of caffeine powder is known to be lethal to humans.

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"Drugs and Controlled Substances". Blachford, Stacey L. and Krapp, Kristine. *The Gale Group, Inc.* Farmington Hills, MI 2003.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Investigating the Environmental Impacts of a Copper Sulfide Mine

BY **KEITH LEONARD AND HUNTER STANLEY**

"The Pebble Mine" is a proposed open-pit mine in Bristol Bay, Alaska. Copper Sulfide mining creates acidic by-products and it is the goal of our experiment to determine what effect those pollutants would have on water supply's ability to support the salmon population.

THE PEBBLE MINE

The Pebble Mining project is a proposed copper sulfide mine in Bristol Bay, Alaska. It would be the largest open-pit mine to date and require the removal and relocation of billions of tons of stone, dirt, and mineral ores, to large structures known as Tailings Damns. Bristol Bay is the last stronghold of Sockeye salmon in the world, accounting for almost 80% of the world's supply. This is a potential environmental disaster.

Alaska is also known for some of the most punishing weather conditions in the United States. Bristol Bay averages close to 160 inches of total precipitation, in addition to winter temperatures far below freezing. In addition, the Alaskan coast sits on the pacific ring of fire, the most seismically active zone on earth.

ACID MINE DRAINAGE (AMD) & TAILINGS DAM FAILURES

Whenever these tailings dams are used to hold metal sulfide mining waste, Acid Mine Drainage (AMD) is created. The Sulfur (from Copper Sulfide) reacts spontaneously with water and oxygen to create sulfuric acid (battery acid). This is then stored in the tailings dams indefinitely along with the free-floating metal ions released during acid formation.

Scientists believe that the combination of the punishing weather conditions and seismic activity could spell disaster for the tailings dams, expelling lots of mineral waste and AMD into the surrounding groundwater.

The specific location of the mine, in the headwaters of Lake Iliamna, is one of the major spawning grounds for sockeye salmon. The baby salmon, or smolt, are highly sensitive to changes in the water conditions.

THE GOAL

Our experiment focused on the rate at which Copper Sulfide and other minerals produce Acid Mine Drainage, and the effect that this acid had on a water supply's ability to support a native salmon population. We aimed to answer such questions as:

•Will AMD affect the amount of dissolved Oxygen in the water?

•Is there a drastic effect on the water's acidity?

•Enough to affect the salmon's biological processes? Their ability to spawn?

THE EXPERIMENT

Our preparation and analysis of polluted water focused on Oxygen Content, and Acidity of mineral compounds dissolved in water at various concentrations, (0.01M, 0.1M, 0.5M, 1M) with each concentration representing a different degree of chemical contamination by the possible mining wastes. We tested several possible mineral pollutants (all representing different aspects of possible pollution): Sodium Sulfide (Na_2S), Copper Sulfate ($CuSO_4$), Iron Sulfate ($FeSO_4$).

OXYGEN DETERMINATION

Dissolved Oxygen created a precipitate with Manganese

Sulfate ($MnSO_4$). A solution of Potassium Iodide (KI) and Sodium Hydroxide (NaOH) was then added in order to stop any excess oxygen from being introduced during the titration. The solution is then acidified and titrated to a starch endpoint with Sodium Thiosulfate ($Na_2S_2O_3$). By determining the amount of thiosulfate required to reach the endpoint of the titration we determined the oxygen concentration.

WATER ACIDITY DETERMINATION

Testing the acidity of the water was a simple process. First pH strips were used to find an accurate range of the actual pH of the water. A pH probe was then calibrated with buffers that represented that range in order to determine the exact pH of the water sample.

EXPECTED OBSERVATIONS

We expected all metals to create a small concentration of sulfuric acid, since a spontaneous reaction of oxygen, water, and sulfur creates this acid. However, we expected the sulfates to create more acid. By nature, sulfides are very insoluble in water, but soluble in acid. As such, as more acid is produced in the solution, the solubility of sulfides increases and thus allows the production of more acid. We aimed to see whether this process could perpetuate itself.

For the oxygen determination, we expected sulfides to spontaneously react with dissolved oxygen and water to go from sulfides (S^{-2}) to sulfates (SO_4^{-2}) and finally to sulfuric acid (H_2SO_4). This process absorbs water, and thus we expected decreased dissolved oxygen content with the metal sulfides. Further, the dissolved oxygen concentration where the contaminant is a metal sulfate should not change, however small changes in the water's composition could always change its components parts in unpredictable ways.

We expected that the pH and other changes in the water's characteristics would be drastic enough to be considered harmful to the native population of salmon and the entire ecosystem that depends on them.

ANALYSIS OF COPPER SULFATE

An increase in the acidity of the solution was observed as the concentration of pollutant rose. This would be expected due to the characteristics of dissolved pollutant

KEITH LEONARD

A solution of manganese sulfate is titrated with potassium iodide as part of the oxygen analysis.

ions. In addition to this increase in acidity, there was an accompanying decrease in the water's oxygen content. Over the molarity range, the amount of oxygen decreased by almost 40%, and this would be characteristically horrible for the salmon population. Both of these characteristic changes would decrease the ability of the water supply to support the salmon population.

ANALYSIS OF SODIUM SUFLIDE

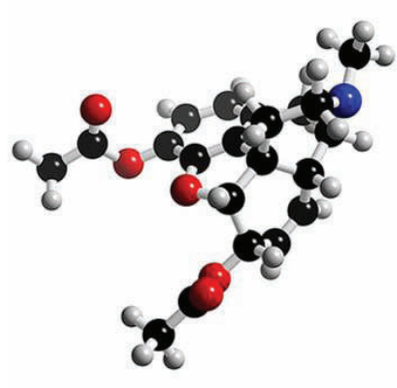
As of now we are hypothesizing that the H_2S formed when the sodium sulfide broke apart in water was less soluble than the NaOH (which is a strong base and thus almost completely breaks apart in solution). Either way, this test demonstrated an unexpected but still harmful effect that this pollutant could have on the water supply.

ANALYSIS OF IRON SULFATE

This pollutant demonstrates the exact changes in acidity that we were expecting to occur with the Sodium Sulfide solutions. As with the Copper Sulfate we see an increase in acidity with increasing molarity. Again, this would be harmful to any species it were to come in contact with.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

The Effect of Biodiesel on Rubber and the Effect of Cold in Biodiesel



BY **ANA SCURIC**

Alternative fuels are becoming increasingly popular. Some of the most common types of alternative fuels are biodiesels, which can be made from either vegetable oil or animal fats. Most often they are made from soybeans, corn, used vegetable oil, and sunflowers.

Switching to biodiesels comes with many benefits. It burns cleaner than pure diesel fuel due to its higher cetane number, and does not add extra CO_2 to the environment when it is plant based. They also clean out gunk left behind by crude diesel fuels which can as a result prolong an engine's life.

Additionally, biodiesels reduce several different types of emissions commonly associated with diesel fuels. Its exhaust does not create much or any carbon monoxide, sulfur dioxide, smog, and the carcinogen PAH.

Yet, converting to biodiesel does come with its own drawbacks. In terms of emissions, Biodiesel may increase the amount of Nitrogen Oxide in the air. The other two main problems one may encounter when switching to biodiesel are issues with it functioning in cold weather and also deterioration of rubber parts within the engine.

EFFECT ON COLD

Background and Procedure:

It is difficult for any diesel engine to perform well in extremely cold weather, but biodiesel fuels are less cold resistant than regular petroleum diesel. In the cold, wax crystals often form within the fuel, making it difficult to compress. Several websites claim that there are ways to go around this problem by adding either anti-gel additives or mixing with regular petroleum diesel.

I placed 4 different samples of fuel in ice to simulate freezing conditions. These fuels were: petroleum diesel #2, B99 (biodiesel), B99 + Power Service Diesel Fuel Supplement, and b99+ Power Service Diesel 911 (which was added after freezing).

ANA SCURIC

FIG. 1: **Diesel #2, B99 Biodiesel with anti-gel additive and pure B99 Biodiesel after being on ice for fifteen minutes.**

Hypothesis:

For initial hypothesis, I expected that the control sample of pure petroleum diesel would make the least amount of wax crystals when placed in a cold environment but otherwise I believe that the samples that contain anti-gel additives will also be more efficient in preventing crystallization.

Observations and Conclusion:

As my hypothesis predicted, diesel did not freeze at conditions of 0°C. In addition, B99 with supplement did not freeze. However, B99 by itself froze in less

than 15 minutes and B99 with post-additive, began to defrost but stayed fairly viscous after it was added. However, in both the biodiesel with supplement and the petroleum diesel, the visual density remained the same. From this experiment I can make a preliminary conclusion that biodiesel is more susceptible to becoming more viscous in colder climates, and must be mixed with additives in order to perform in these conditions.

Viton (Synthetic Rubber) and Non-Synthetic in B99 biodiesel

Day	Mass Viton (g)	Mass Rubber (g)
1	0.16	0.10
5	0.15	0.10
13	0.16	0.10
28	0.16	0.10
51	0.16	0.10
60	0.16	0.11

However, more experiments at varying temperatures must be done in order to get a better picture.

This can be done by using a similar set-up, but instead of filling the bucket full of ice, a combination of water and ice can be used to vary the temperature of the environment that the biodiesel is placed in. More ice could be used to creaAte conditions closer to 0°C and less ice can be used to make conditions slightly colder than room temperature.

A control could also be run at either freezing (or similarly cold) conditions on the two anti-gel additives to observe how they react to cold conditions. In addition, Diesel #1 was not used in this experiment because it is difficult to find, but it would be interesting to test since it already has several additives that help it perform better in cold weather since it is mostly used by large trucks.

EFFECT ON RUBBER

Background and Procedure:

Biodiesel is more acidic than regular diesel, so after some time it begins to wear away the rubber in the engine and maybe even other parts of the car. While biodiesel is usually used to clean out any residue that regular diesel may leave behind, extended use of the fuel can also have negative effects after a certain period of time. On 1/14/13 I started an experiment using 2 types of rubbers (synthetic and non-synthetic) were tested by being suspended in pure B99 biodiesel. I massed them periodically, after washing them off with water, to track the rate of deterioration.

Hypothesis:

I believe that Viton will deteriorate at a slower rate than non-synthetic rubber because Viton is engineered in hopes of being able to handle more acidic fuels.

Conclusions:

Visually there does not seem to be any difference between a new rubber ring and the submerged one, but when squeezed, the non-synthetic rubber ring that was submerged in diesel was much less resistant than a new ring. To test this further, a two rubber rings can be placed on a rod of some sort and one submerged in biodiesel and the other left on the lab bench. The two rings can be compared by both how much they stretch, if at all, and by how resistant they are to squeezing.

Unfortunately, the rubber rings were not suspended long enough to show any significant mass change or deterioration. However, extra controls for the rings sitting in biodiesel could have been run as the final steps of this experiment by placing a Viton and a non-synthetic rubber ring into a solution of acid (most likely low molar HCl) to have a visual for how each rubber would react in a purely acidic environment. A pH test on both biodiesel and regular diesel #2 would need to be performed to see whether the assumptions about biodiesel being more acidic are correct.

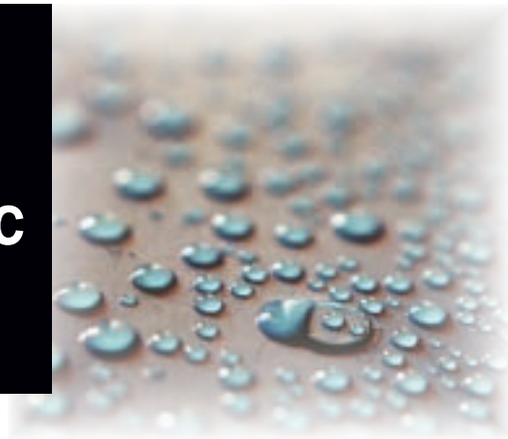
REFERENCES

•http://journeytoforever.org/biodiesel.html#facts

•Biodiesel America by Josh Tickell

STUDIES IN SCIENTIFIC RESEARCH PROJECT

A Drag-Reducing Hydrophobic Coating Experiment



BY **JAMES WU AND AUSTIN YOO**

Drag forces in water slow naval vessels down and can result in **high fuel consumption** and **long travel times**. In this experiment, we attempt to reduce these drag forces through applications of **hydrophobic coatings**.

Today, the world faces rising gas prices and dwindling fossil fuel supplies. Eventually, there will not be enough fuel on this planet to support all of the manufacturing and mechanical labor we perform. As a result, we must learn not only to find better fuel alternatives such as electricity, but also to conserve fuel when we still have it. In this experiment, we attempt to conserve fuel through the use of hydrophobic coatings on boat hulls.

Hydrophobic coatings are water-repelling barriers that can be applied to a number of material surfaces. Applications of these coatings can range from germ-repelling medical coats to waterproof phones to drag-resistant objects travelling through water. We will test the last mentioned application on boats and attempt to greatly reduce drag forces due to water and calculate the fuel conserved as a result. We can then determine whether having hydrophobic coatings on boats is a practical method of conserving fuel that can be used widely throughout the world.

METHOD

We used Rubberizeit!™ liquid rubber to coat a wooden trough and thus create a controlled environment in which we ran our experiments with the boats. We then filled the trough with tap water and bleach in order to keep the water clean.

We purchased four boats, naming them 1, 2, A, and B, respectively. We used sandpaper to sand the hulls of each boat in order to increase surface area and to increase the drag forces on the boat. We then drilled one small hole in the front of each boat so that we can attach fishing wire as part of our pulley system. We weighed each boat before applying the hydrophobic spray and recorded the time it took for each boat to cross the trough. Our pulley system consists of a clamp, a pulley, fishing wire, and a 10g weight. We would place the attached boat at the opposite end of the trough and let it go, using the weight to pull the boat across. After testing the uncoated boats, we then sprayed on one layer of hydrophobic spray on each boat to be tested, weighed each sprayed boat, and recorded the time it takes for each boat to cross the trough. By doing this, we can calculate the velocity of both boats and see if the hydrophobic sprays affect the boat's travel.

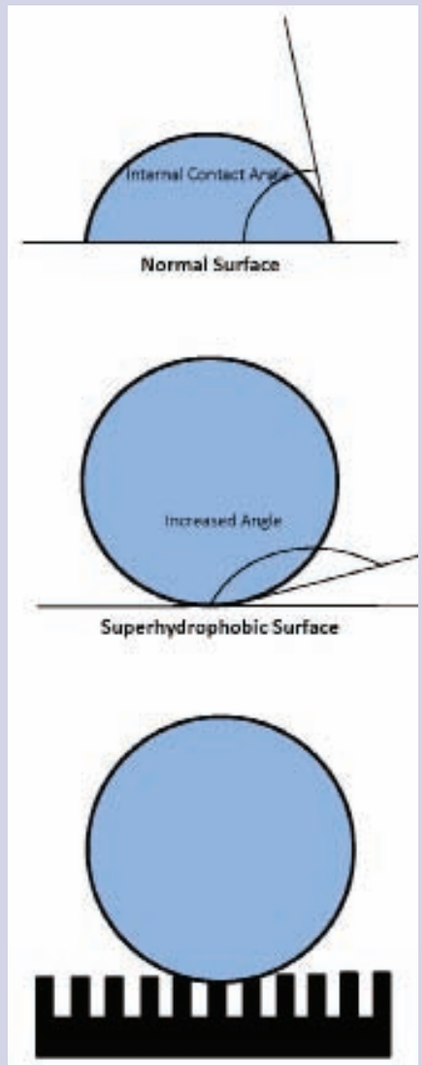
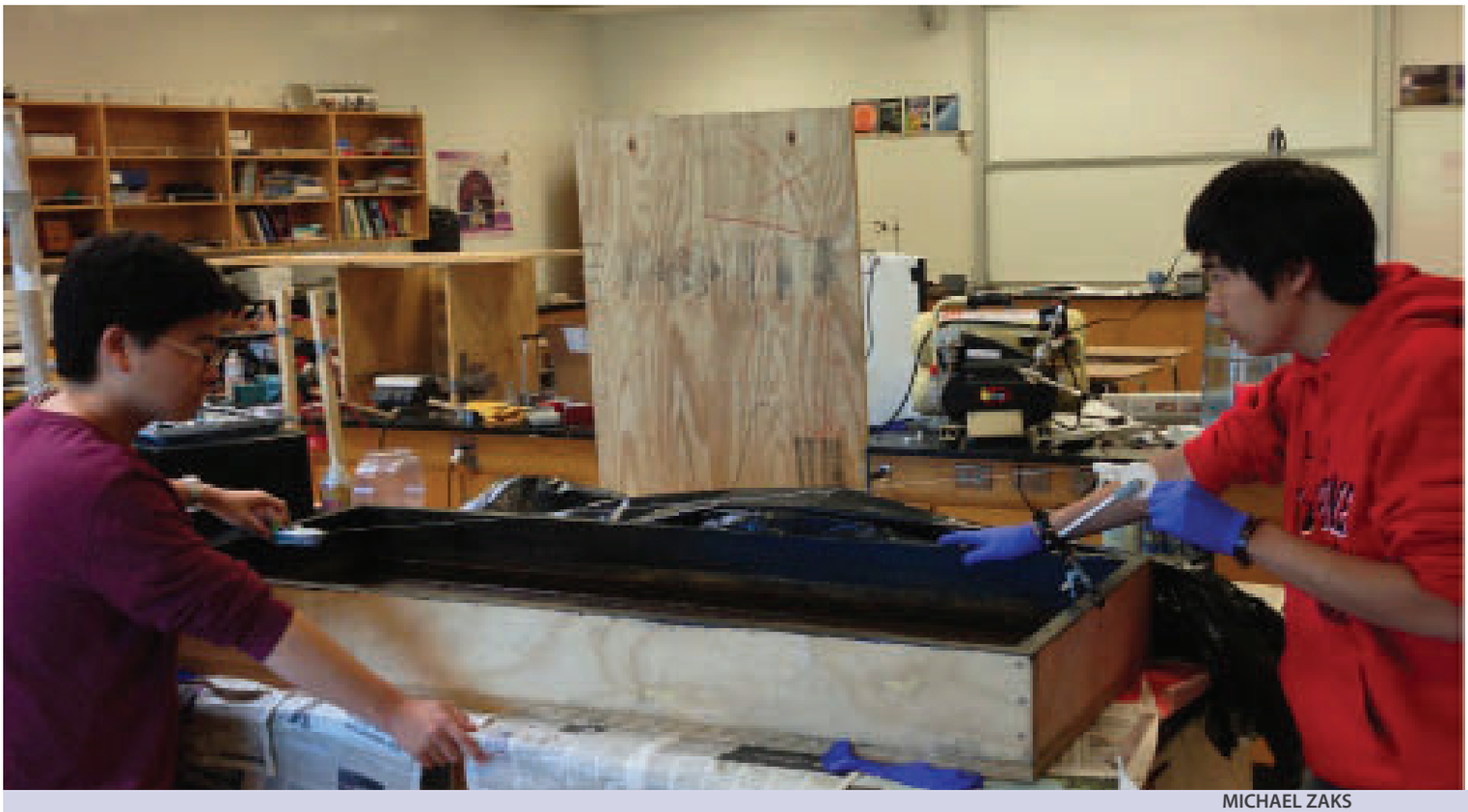


FIG. 1: The difference between an uncoated surface's and a coated surface's effect on water droplets.



MICHAEL ZAKS

Austin Yoo '13, left, and James Wu '13, right, work on the the pulley system used to pull the boats across the trough for their project. This system provides a constant pulling force on the boats.

We initially started with a coating for satellite receivers, but the spray can malfunctioned, and we couldn't ensure a proper coating. Thus, we ordered a second hydrophobic spray, but that spray did not work at all – it didn't seem to stay on the boats. We then found a third hydrophobic spray used to waterproof shoes, and we discovered that the spray worked quite well. Boat 1 was coated with the first spray, while boats 2 and A were coated with the third.

RESULTS

After driving the boats across the trough according to the procedure, we initially found that the boat that had the coating was actually slower than the control boat, contrary to our predictions.

Over winter break, we had emptied the trough to prevent mildew from forming, but after we came back, we found that the bleach seemed to not only bleach the rubber, but also cause a reaction with the metal lining the trough. After winter break, we refilled the trough with water and smaller amounts of bleach, and it seems to accumulate less of the strange substance. Thus, we can conclude that the bleach plays a big role in the apparent corrosion of the rubber or metal.

We tested both boats 2 and A, and we found that the average time the uncoated boat 2 took to travel across the trough was 2.6 seconds, and the average time the uncoated boat A took to travel across the trough was 2.8 seconds. After coating both boats, boat 2 still had an average time of 2.6 seconds, and boat A still had an average time of 2.8 seconds.

We concluded that there was no appreciable time discrepancy between the uncoated versions and the coated versions of the boats. We concluded that there are two possible reasons for this:

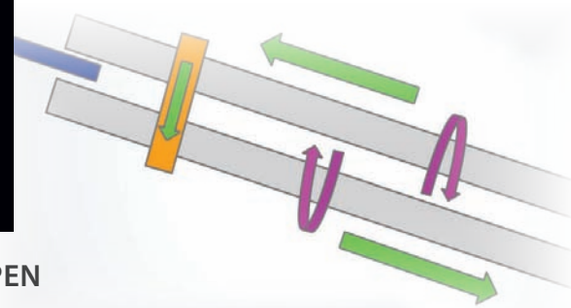
1.) that the boats are too small for the coating to generate a substantial change in speed, and thus we need to experiment on larger boats.

2.) that the coating does not have an effect on the drag forces, that the water still gets pushed around the same way.

The second hypothesis may mean that paintings and extra coatings on vehicles such as airplanes or cars are unnecessary.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Railguns in Aerospace



BY **DARA MOGHAVEM, CHARLIE ANDREWS-JUBELT** AND **JOSH LAPPEN**

Recently, **railguns** have found many applications as **high velocity, high energy launch** systems for both military purposes as a weapon and peaceful ones. The purpose of this experiment is to **investigate these peaceful applications.**

While railguns may not be necessary to launch planes for commercial flight in the present, as aviation evolves, they may be found useful as a means of assisting planes in takeoff and landing. Due to constraints on runway space, taking off and landing is currently a difficult and risky process on aircraft carriers. Railgun technology has the potential to make carrier take-offs and landings less complex, dangerous, and difficult. Such systems could save space and serve as a more versatile technology than the floating-runway systems currently employed.

Railguns also show great promise in cosmonautics and related fields. As space transportation, communications, and research continue to develop and privatize, a cheaper, more effective system for sending crafts into orbit and beyond and landing them back on Earth would be instrumental. They could replace large-scale propulsion systems for single-use craft, which would substantially reduce the cost, resource consumption, and technological complexity of space exploration.

A railgun relies on two parallel conductive rails connected to a power source and a connecting armature between those rails.

In order to investigate the potential of railgun systems in aeronautics, we designed and built a small-scale, relatively low-energy railgun, and then conducted tests to determine whether it might be a practical device for use in launch or landing of aircraft and spacecraft using a lightweight, conductive airfoil.

CONCEPTS

A railgun relies on two parallel conductive rails connected to a power source and a connecting armature - also conductive - between those rails. Ideally, a rail launch system would employ an air-cored design, meaning that no outside magnetic field would be set up in the field between the rails that could interfere with the intended payload atop the armature. Instead, when the switch is flipped and current flows through one rail, across the armature, and back to the battery through the other rail, a magnetic field perpendicular to the plane of the rails is induced as shown by the Biot-Savart Law, $B = u0I/(2\pi s)$ where "B" is the magnitude of the magnetic field, "u0" is the permeability constant, "I" is the current, and "s" is the distance from one of the rails. Since there exists a magnetic field perpendicular to an electrical current, a Lorentz force acts on the armature, directed away from the power source with a magnitude given by FB = IdB, where "d" is the length of the armature.

APPARATUS

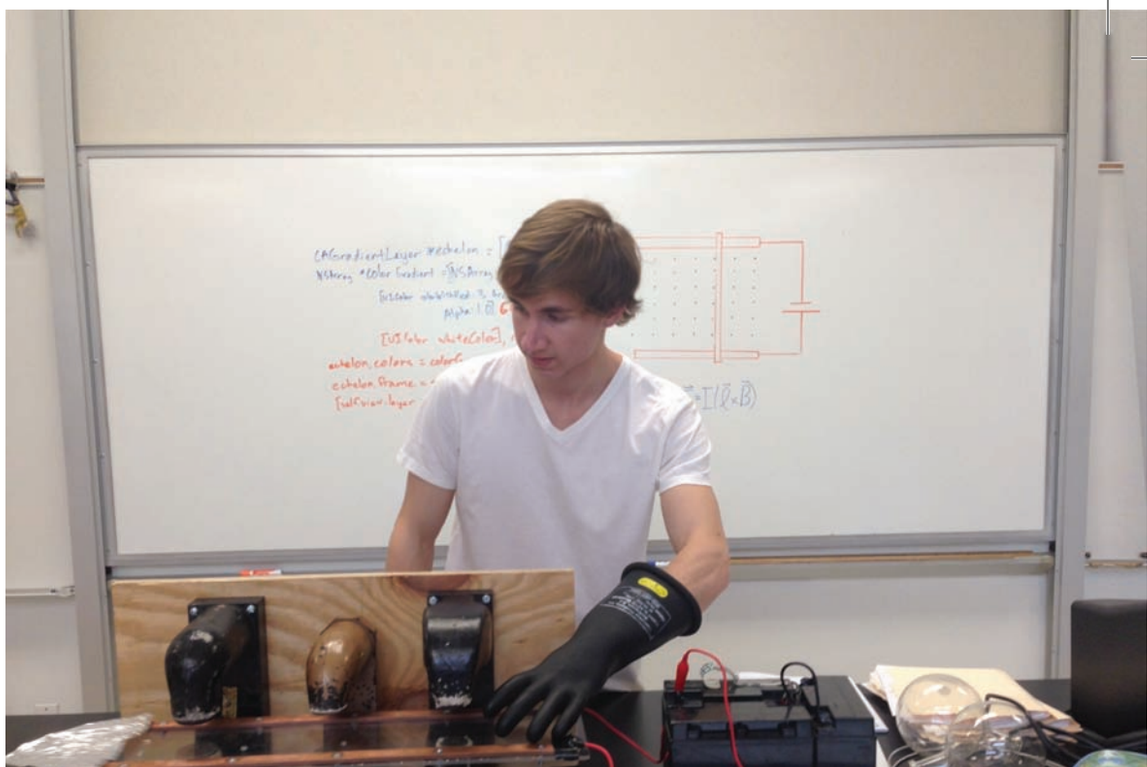
Construction of an effective railgun apparatus proved to be the greatest challenge of our experiment. An air-core design would be preferable for accelerating aircraft which could be impeded by the presence of a large magnet above and below the rails, especially as they begin to take off. However, because repeated trials of air core systems proved unsuccessful, we added magnets that establish a permanent field perpendicular to the rails, increasing the Lorentz force on armatures. Similarly, we substituted car batteries in series for the bank of capacitors traditionally used to drive electrical currents because they allow for consecutive trials, don't require recharging as frequently, and provide safer currents.

EXPERIMENT

Initially, we tried adapting a previously-existing laboratory railgun. By widening the gap between the rails and increasing the voltage of the power source (maximizing both the current and the induced magnetic field) we hoped to create a system adequate for our purposes.

However, we quickly found that this railgun system was too small and its resistance too high to be of practical use, and so we decided to build a railgun from scratch. We mounted deoxygenated copper rails on polycarbonate and connected them to a series of car batteries adding to 30V. The width and composition of the rails allowed for consistent contact with the armature and very low resistance in the circuit. This contributed to a higher current and thus a far greater force on the armature than our previous apparatus was capable of. The induced magnetic field of the railgun was also bolstered by the addition of several high-powered magnets along the track. Once complete, the new railgun proved to be operational with a low force and consistently capable of launching light projectiles.

The next task was to create an unmanned craft that would rest on both rails of the launching device, allowing the plane to act as the railgun's conductive armature and recipient of the Lorentz force. To prevent the craft from melting, we chose a material with high thermal as well as electrical conductivity and tried to maximize contact surface with the rails to make sure current flowed through it and the Lorentz force acted on it along the entire length of the railgun. We also endeavored to minimize friction with the rails. To accomplish these goals, we chose aluminum foil, which works well due to its high conductivity and light weight. However, the material is subject to abrasion over time, requiring the fabrication of new armatures every several launches.



AUSTIN CHAN

Charlie Andrews '13 releases the prototype airfoil (seen far left in the picture) into contact with the live rails of the railgun apparatus, firing it.

CONCLUSION

The last questions posed by this experiment are those of application and practicality. Railgun systems hold great promise in the field of flight and spaceflight, especially for the launching of orbit-bound cargoes. However, many obstacles remain before railguns can be applied as launch systems on a larger scale.

While our apparatus proved capable of launching relatively small airfoils, it may still be that the energy expenditure required to successfully launch an actual aircraft is simply too prohibitive. It is also possible that it may prove impractical or even impossible to isolate the interior of the plane from the current and fields created by the railgun. These problems and others could obstruct the practicality of railgun takeoff and landing systems. However, the larger goal of this project was to investigate the feasibility of railguns in flight, and so obstacles in one or even several of these areas do not necessarily devalue the concept. Railguns may show the most promise in launch, not takeoff, systems. Putting payloads into orbit is a very energy- and resource-intensive process, and one which is more and more frequently executed. It is in this application which railgun systems may prove to be of greatest non-military use.

Starting a Legacy

HWJS co-founders **Allen Miller '07** and **Justin Chow '07** look back on their time in Studies in Scientific Research, then a Directed Study for seniors, and talk about how the experiences in research have transferred over to starting their careers.

'Innovating in Class and Beyond'

BY ALLEN MILLER '07

*Back in the Spring of 2007, Justin Chow '07 and I were seniors with **big imaginations** and a **keen interest in science and technology**.*

With the expansion of the science program at Harvard-Westlake to include what was then the Directed Studies in Scientific Research now known more simply as SSR, the time was ripe to launch the HWJS, one of the first high-school publications focused on innovation and research in the sciences and engineering. The experience of launching that first issue, from the initial brainstorming sessions with Dr. Nassar in Munger to the late nights spent editing articles to that first moment of leafing through issue 1 of the journal, fresh off the press at Charlie Chan Printing, was one of the most valuable experiences we both had in high-school. The support we received from Dr. Nassar and the Harvard-Westlake administration was truly remarkable and the two of us couldn't be more thankful for that opportunity.

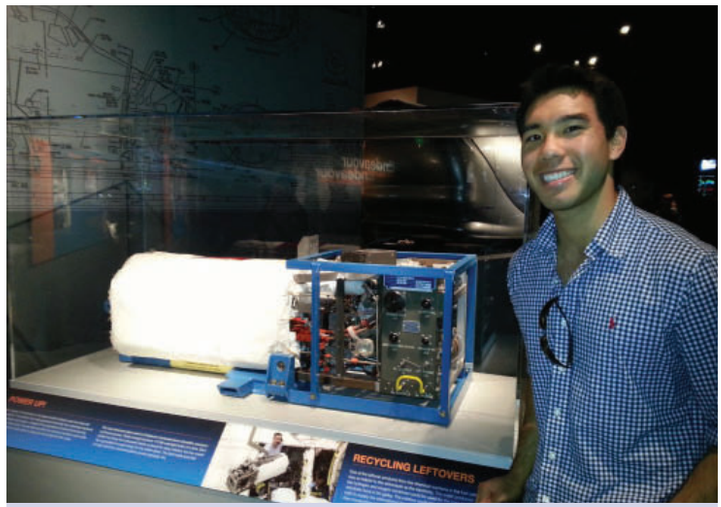
Justin went on to continue down the path of becoming one of the leading young researchers in power and energy, studying engineering at Columbia as an undergrad and continuing as a graduate student at the National Fuel Cell Research Center at UC Irvine. I also continued to be interested in research but focused my efforts on understanding the synergies that occur at the intersection of education, business and technology. Through the Cornell Presidential Research Fellowship I received to fund my honors thesis as an undergraduate, I was able to travel to Doha, Qatar to study the growth of research, innovation and business at satellite campuses in Gulf nations.

My time at Cornell affirmed the belief I had built at Harvard-Westlake that research can often lead to cutting-edge solutions to some of society's biggest challenges in areas as diverse as healthcare, software security and alternative energy. Yet without the appropriate funding and business acumen this innovation never makes it to the market where it can be more widely available for public use. Increasingly we need people—entrepreneurs, venture capitalists, industry professionals, etc.,—who are able to take research and apply it in ways that are commercially and socially successful.

This fall I will be attending Columbia Business School to further develop my interests in supporting the commercialization of ideas that come out of entrepreneurial ecosystems—whether at university labs, startup accelerators or maybe, just maybe, a high school class. As many of you think about college, research and what you hope to become in the future—always be an innovator. Get involved at a research lab that excites you, launch that big idea you've always had but never acted on or build something that you're truly passionate about. There's no better time than now to do something entrepreneurial. And if you think you've got something big, let's chat.

PRINTED WITH PERMISSION OF ALLEN MILLER

Allen Miller '07 will be heading to Columbia Universigty graduate business school next fall and hopes to further develop his entrepreneurial skills.



PRINTED WITH PERMISSION OF JUSTIN CHOW

Justin Chow '07 recently finished his master's degree in mechanical engineering at UC Irvine in the Advanced Power and Energy Program.

'Out of the Classroom'

BY JUSTIN CHOW '07

Bundled in the memories of HW is one in which Allen Miller '07 and I were sitting around talking aimlessly like we often did. Somehow during our chat we had progressed into ***discussing the utility of scientific research.***

We both had had our fair share of research throughout high school, and during our last year at H-W, enrolled in Studies in Scientific Research where we teamed up to investigate the wonderful role of hormones in acne (still not sure why we picked this topic). Among the questions tossed around were: Why do we research? Who cares? And, does it matter? From these nihilistic questions we realized that research has no value if it cannot be shared. A discovery can be considered great within the scientific community, but for it to be truly great it must be effectively disseminated to society.

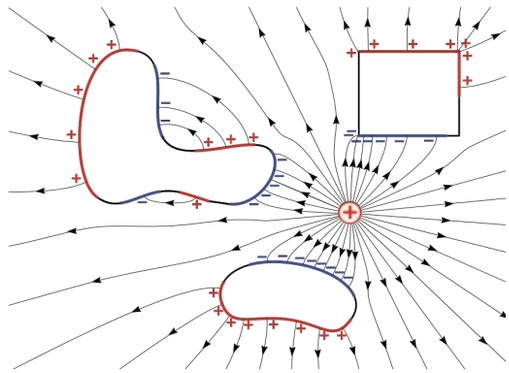
Thus, Allen and I began to work with Dr. Nassar to create a journal that could empower those of us in SSR to capture the spirit of research and allow us to be proud of our accomplishments, but at the same time be readable for those non-science literate. In addition, in the name of promoting the joy of science, we wanted it to be a fun read for all. The product of our combined efforts was the founding of the HWJS.

Today, when I look back at HW and admire how much the science program, the HWJS, and SSR, has grown, I feel nothing but appreciation for the teachers and resources that made it all happen. Most importantly, I recognize how powerful my earliest research experiences were, both in and outside of HW, for my path from high school scientist to graduate student researcher. Dabbling in research early exposed me to a set of learning skills that cannot be gleaned in the classroom. Learning theory is one matter; applying it is another. This can be especially true if working alongside university and graduate students, who bring a much deeper perspective to the subject at hand. It was these nascent research opportunities that were the reference points for the process of choosing the field of science in which I would be most happy. In my case, the valuable physics and electrical engineering summer research experiences I had at UCLA guided me towards environmental engineering in college, ultimately channeling me to where I am now in mechanical engineering, researching advanced power generation. Conversely, it is quite possible that one builds reservation towards research if an experience is not enjoyable, in which case is this conclusion too is a win.

At many points in my academic timeline, I was unsure of my next move. This is why it is essential to be proactive from the start. Start early and be the initiator—you never know where your next step will take you.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Investigating Applications of the Electrostatic Effect



BY **RHETT GENTILE**

The electrostatic effect is a way of moving and controlling microscopic particles. This project investigates whether the effect can be scaled to affect macroscopic amounts of substance.

All matter is comprised of charged particles: The base elements of atoms are positive protons, neutral neutrons, and negative electrons. When atoms bond with other atoms to form molecules, negative charges shift around, creating areas of relatively higher and lower electronegativity, effectively giving molecules positive and negative poles.

Being charged, atoms and molecules can be affected by electrical and magnetic fields. On a dry day, hair strands will rub against each other, develop charge, and repel, causing frizzy hair. On a less irritating note, air scrubbers for factories work using this process. Positive particulate matter in industrial exhaust is attracted to negatively charged electrodes, pulling the particles out of the air stream for easy disposal.

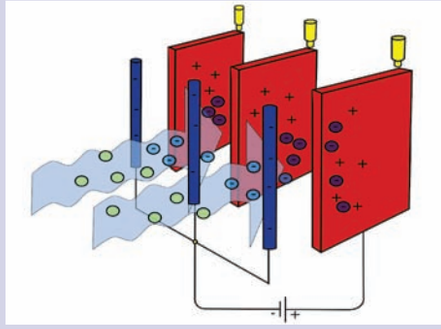


FIG. 1: An electrostatic precipitator

CONCEPTS

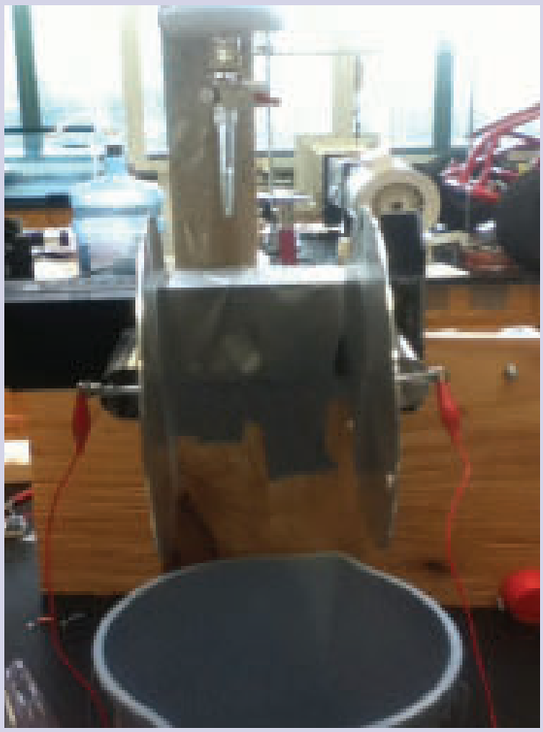
The Electrostatic Effect

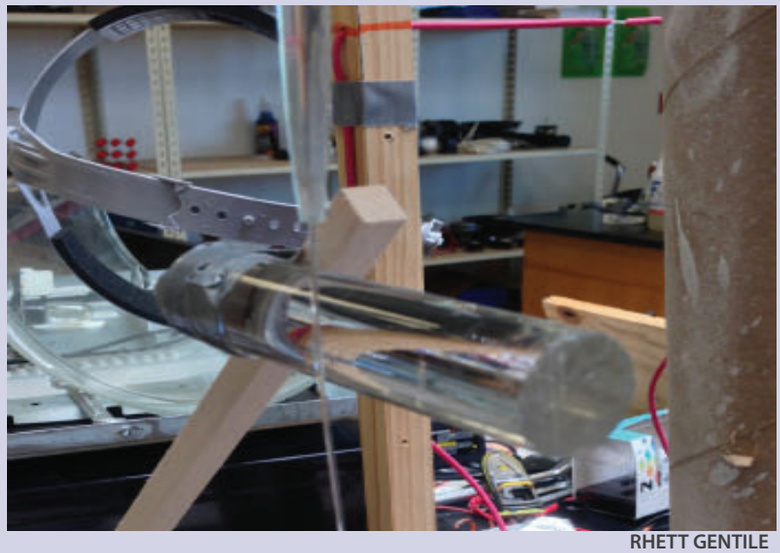
Electrostatics deals with the phenomena of slow-moving or stationary electrical charges: the word electrostatic itself comes from the Greek words "elektron", meaning amber, and "statikos" meaning to stand. Electricity itself was named for amber because of the substances triboelectric properties: when it is rubbed with a cloth or similar material, charge is mechanically transported from one substance to another. Triboelectricity is responsible for most of the static electricity that we observe day-to-day, from hair frizz to lightning. Static charges can also be induced by other static charges, which force mobile charges in conducting objects to align with the electrical field of the object[2].

PROGRESS

So far, I have managed to devise the system that will be used to test the strength of the Electrostatic effect. I quickly realized that creating strong static charges with triboelectric interaction would not be a reliable way to run tests: The charges produced are in the hundreds of thousands of volts, but have milli- and micro-coloumb amounts of charge. Measuring the voltage of such charges requires extremely sensitive equipment, as the high voltages involved tend to instantly discharge the static electricity across the voltmeter. So, I decided to make use of a large demonstration capacitor instead.With this equipment I am able to adjust the distance between plates and the voltage applied between them. Using the formulae $C V = Q$ and $C = \varepsilon A/d$, I can control for capacitance, voltage, or charge.

I also required a thin, easily manipulated and relatively constant stream of water for my experiment, and so I constructed a simple water tower with a stopcock attached to serve as a water supply. The large volume of the tank ensures that the pressure of the water remains constant, and the stopcock allows me to adjust the flow rate of the water and so the mass of water passing by the electrodes at any given time. The capacitor is now attached to a variable voltage source or car battery, and





RHETT GENTILE

FIG. 1: Above, deflection of water using triboelectrically generated charges on a Lucite bar

FIG. 2: Left, demonstration capacitor set up to bend water using accumulated charge. The capacitor is positioned to attract water towards the left plate.

the deviation of the angle measured.

I also constructed a simple apparatus consisting of a stranded wire suspended between two posts through which current could be passed to test the strength of the surface charges on a current carrying wire, as shown below:

PRELIMINARY RESULTS

The first set of results that I have obtained have clearly demonstrated that the surface charge accumulated on a current-carrying wire is far too small to affect a stream of water of any size. At 5 Amperes of current, no noticeable deflection was produced in the stream, and the variable voltage source that I was using refused to allow any more current to flow through the system. Similarly, a large potential across the capacitor at a very small displacement between the plates failed to produce any noticeable deflection.

Further tests were conducted to determine whether any deviation would even be measurable. Using rabbit fur on Lucite, a small deviation was produced, but attempting to measure the voltage of the static charge discharged the Lucite bar. Tests with diamagnetic repulsion similarly yielded no displacement.

CONCLUSION

My tests have demonstrated that the electrostatic effect on water is an extremely weak one. Producing the necessary voltages is dangerous and they cannot be measured, and only extremely high voltages seem to be capable of producing electric fields powerful enough to bend streams of water. More powerful, precise equipment would be necessary to produce significant data.

Water is a critical resource in almost all areas of human endeavor, and high purities are necessary for certain applications such as the manufacture of semiconductors. By providing a method of moving water without direct contact with moving parts, contamination with metal flecks or grease, two byproducts of common mechanical system, can be completely avoided. By avoiding moving parts entirely, the failure rate of delicate systems can be dramatically decreased, as moving parts are the most failure-prone part of any system.

RESOURCES

•Evan Mason, http://en.wikipedia.org/wiki/File:Electrostatic_precipitator.svg

•http://en.wikipedia.org/wiki/Electrostatics

STUDIES IN SCIENTIFIC RESEARCH PROJECT

A Study of Airfoils in Ground Effect

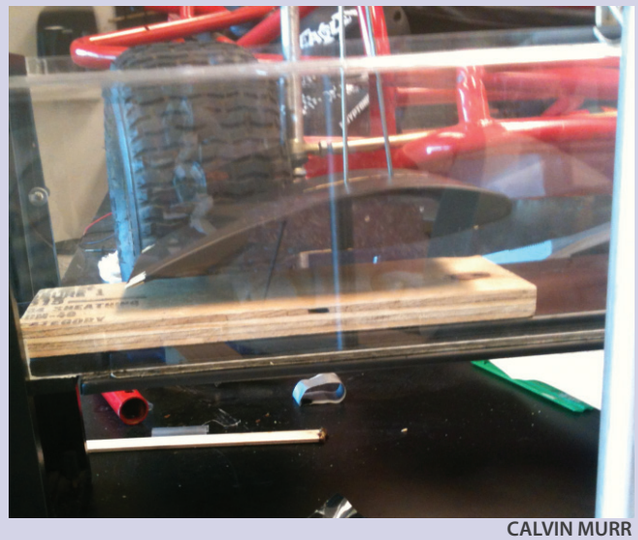
BY **CALVIN MURR**

Ground effect could potentially offer large efficiency gains in the design of an airplane. My project is to observe how airfoils, the shape of the wings, behave in ground effect.

Drag and lift are the two aerodynamic forces that dictate the way planes are designed. Lift, as the name implies, is a forced directed upwards and is caused by a pressure differential across the span of a airfoil. Drag is a force directed opposite to the direction of travel of an object moving through a fluid, though its causes are more complex. The three main types are skin friction drag, caused by friction between the fluid and the surface of the wing, form drag, caused by a pressure differential between the front and back of the wing, and vortex drag, caused by swirling cores of high velocity air that form when flows of differing pressure mix at the edges of the wing. All three of these drag forces make the planes have to carry more fuel and weight to travel a given distance. One way to minimize drag is by exploiting a phenomena called ground effect, by which an airfoil's efficiency increases drastically when placed in close proximity with the ground. My goal was to research whether ground effect is a viable option in aircraft design and to create a wind tunnel which allowed for accurate and reliable testing.

In my project, l studied ground effect using a basic wing shape. Ground effect effectively increases aerodynamic efficiency at the tips of the wings by 'sealing' the high pressure, slower moving air flow on the underside of the wing from the low pressure, high velocity flow on the top side of the wing. This means that the extreme ends of the wing maintain a pressure differential and thus produce more lift. Because the flow on the top and bottom of the wing are unable to mix, the wing tip vortices that contribute to drag are disrupted.

One of the most challenging aspects of the project was in setting up the wind tunnel to be able to give reliable data throughout the test. If there was turbulence in the flow produced by the fan which feeds the tunnel, then it would render any data I would have collected from the tests meaningless. To measure the lift in my experiment, I attached a scale to the airfoil section, and then measured the force exerted on the scale. I collected data from wind tunnel tests, while I used wooden blocks on the floor of my wind tunnel to vary the distance between the wing section and the floor of the wind tunnel. I have found that the total lifting force does indeed increase when the wing is closer to the floor. In my first test, I placed a 10 mm plank under the airfoil and found that the measured lift force increased by 1.3 Newtons, a marked improvement. However, when I added a further wooden plank 5 mm wooden plank, the lift increased, though less than the first plank test at 1.1 Newtons. This is due to the plank disrupting the airflow around the wing.



CALVIN MURR

FIG. 1: The rig used to conduct testing. The airfoil section is connected to a scale and the distance between the floor and the wing is varied using the wooden block..

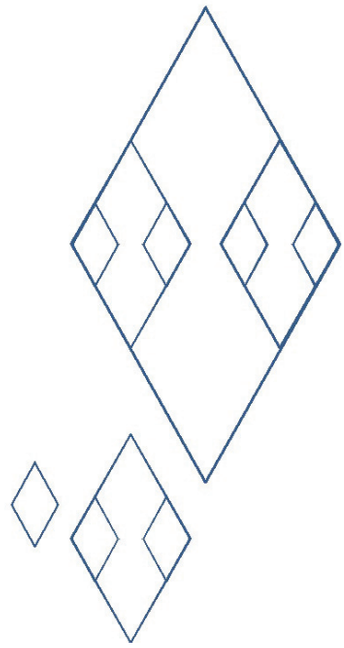
The results I gathered do prove the basic fundamentals of ground effect; that an airfoil, when placed in close proximity to the ground, will produce more lift and less drag for a given wingspan.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Fractal Resistor

BY **JOSHUA SWANSON**

An electrical circuit made into a fractal shape is proposed here. The amount of wire and labor that would be needed to actually build these circuits is discussed.



Fractals are essentially self-similar patterns, i.e., patterns that repeat themselves on all scales. Fractals can be seen all throughout nature and are beginning to be scene in technology.

Kirchhoff's circuit laws for resistors are that the equivalent resistance of two resistors in series is the sum of the two resistances, and the reciprocal equivalent resistance is equal to the sum of the reciprocals of the two resistors.

But what would happen if an electrical circuit were made into a fractal shape? That is the problem that will be discussed. The amount of wire and labor that would be needed to actually build these circuits are beyond the resources available however, so this paper is purely theoretical.

The fractals use are a branching fractal. The first iteration of the fractal is a rhombus, with each of the segment being a resistor. The second iteration is two of the first iteration side by side with additional segments that connect the tops of the rhombuses to a point, as well as the bottoms. This pattern could only ever be made to a finite iteration.

Before going into applications of these circuits, the characteristics of the circuit need to be assessed.

If the resistance of a segment is equal to R, then the effective resistance of an iteration n is $R_n=R(2^{n+3}-1)/(2^{n+1})$. The limit of R_n as n goes to infinity thus is 4R.

The current through segments of the splits as the paths split. Ohm's law is V=IR. If the voltage across the circuit is assumed to be the same in all iterations, perhaps because of a battery, then the current for any iteration can be found. The voltage across the circuit is V_T. Thus the current of a given iteration, I_n, is $I_n=(V_T)(2^{n+1})/(R(2^{n+3}-1))$. It is notable that the limit of I_n as n goes to infinity is $V_T/4R$

A possible use for a resistor is to heat, so the power may be significant. Power can be calculated using P=IV. So thus the power output of the resistor at a given iteration is $P_n==(V_T)^2(2^{n+1})/(R(2^{n+3}-1))$. So the limit of P_n as n goes to infinity is $V_T^2/4R$.

Another important characteristic is the total length of wire used. The total length of wire used, if a segment has length L, is $L_n= L(2^{n+3} – 4)$.

Example:

If V_T = 100 v, R = 5 ohms, and L = 1 meter

To five iterations: R_5=19.92 ohms, I_5 = 5.02 amps, P_5 = 501.96 watts, and L_5=252 meters.

To ten iterations: R_{10}=19.99, I_{10}= 5.00 amps, P_{10} = 500.06 watts, and L_{10} = 8188 meters.

As n goes to infinity: R = 20 ohms, I = 5 amps, P = 500 watts, and L is infinite.

CONCLUSION

The first theorized usage of a fractal-shaped circuit was to allow long distance currents to flow through them, since the power loss would be the same on any scale, roughly. However, with the amounts of wire needed would require materials not yet produced in a large scale (such as grapheme) and therefore make fractal resistors at this point purely theoretical.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Unmanned Aerial Vehicles

BY **MICHAEL GROMIS**

Bringing robotics to the skies, drones have the capbility to help mankind, whether delivering your shoes from Zappos or detecting land mines. The first step towards automating delivery with drones is to learn how they work.

Unmanned aerial vehicles (UAVs) are pilotless aircraft which lend us new ways to automate our lives. Though, we imagine drones as military attack planes, their capabilities stretch far beyond the realm of warfare. A remote control airplane outfitted with a thermal sensor can locate survivors on a search-and-rescue mission or monitor endangered species dispersed across a large area.

Though we have the ability to efficiently transport electrons through an integrated circuit, we cannot transfer matter quickly and efficiently, relying on delivery trucks to sluggishly deliver our packages. A quadrotor (an aircraft powered by four rotors) could easily maneuver a metropolitan zone and deliver a diverse payload ranging from food, to mail, or to your shoes from Zappos. Such a network of drones could simplify construction by transporting materials to the build site, or rather, delivering completed components from an offsite plant to the worksite. Streets will become less congested and deaths related to delivery and semi-truck accidents will diminish. Drones must navegate diverse terrains, requiring them to travel long distances and land in limited areas without runways. A possible model for future drones could be one that combines the characteristics of both plane and quadrotor - long range flight and maneuverability. The V-22 Osprey, a tilt rotor aircraft, is able to rotate its rotors transform between flying and hovering states. A drone that could mimick the osprey could fly long distances and land precisely in a small area.

With such a technology, food and medical supplies could be dropped into remote places where roads and other infrastructure do not exist to support ground transit. Disaster stricken regions could receive aid quickly, on a wide scale, and without the need for human pilots to risk their lives. Drones can dramatically improve underdeveloped or impoverished regions by transporting medical supplies, food, and water, which would lift children's responsibilities to help support their families and enable them to attend school. 33 million primary school-aged children in Sub-Saharan Africa do not go to school, and 40% of Africans over the age of 15 are illiterate.

Capitalizing on the importance of improved delivery technology, the purpose of this study is to understand how to build an autonomous drone and drop a payload into an area. The experiment will be divided into three parts.

PART 1: BUILDING THE PLANE

The first step of the process is to build a plane. Using a Bixler airplane, equipped with elevators, ailerons, rudder, and a push prop (a backward facing motor and propeller). The Bixler was chosen due to its simple design, low price, and relative easiness to operate.

Next, the electronics were assembled. The ESC was soldered to the motor and the servos had to be attached to the Turnigy 9x receiver. The order in which the ESC's three bullet connectors is important; if after activating the throttle, the motor spins counter clockwise, reverse two connectors to spin the motor clockwise.

PART 2: IMPLEMENT ANATOMY

After constructing the Bixler, I implemented the autonomous feature into the plane. Using Ardupilot, a custom Arduino/IMU board, an R/C plane can be converted into an autonomous drone that can follow waypoints or

establish its own path. To install the Ardupilot, it should be facing forward (indicated by an arrow along the side of the board). The board was velcroed into place; however other facening methods such as screwing it into a base would be better for keeping the board still, straight, and safe from coming loose. The electronics must be adapted to the Ardupilot. First, the servos must be connected to the output pins (1-4). Female-female pwm cables must be attatched from the input pin on the Ardupilot to the respective channel pins on the receiver. The ESC's pwm cable should be plugged into the the throttle output pin. GPS and the telemetry unit should be attatched to their respective ports on the Ardupilot.

CHARLIE ANDREWS

Michael Gromis '13 tests the plane's autonomous mode before takeoff to ensure elevators and ailerons respond to movement.

Having a newly assembled drone, I turned to Mission Planner Mav 1, an easy-to-use, open source ground station program that enables me to set waypoints, calibrate my transmitter, and change flight modes. So far, the plane has flown autonomously among a series of waypoints, and also can loiter (circle) around programmed coordinates.

PART 3: BUILD AND TEST PACKAGE DROPPER

Currently, I am adapting the ardupilot's arduino code which dictates all automated functions onboard to accommodate another servo input.

I am creating a compartment on the bottom of the plane, which, coupled with the servo, will open and close to drop a small package.

GOALS/CONCLUSION

"Care Package" has been successful so far. After completing the dropper, I plan to improve the plane's automated maneuverability by changing the code's protocol for control surface movements and by adding an airspeed sensor which can better correct the plane's heading.

Continuing in the direction of creating an effective drone, I plan to study a drone's fuel efficiency and aerodynamics so I may optimize its range – I plan to experiment with batteries, solar charging, decreasing drag, and implementing autonomous thermal hunting. The culmination of such experiments may create a tool that will eradicate poverty and winch humanity's standard of living.

```
Long x = location.getX()
Long y = location.getY()
Long z = Location.getZ()
If(Math.abs(x-dropx < range && Math.abs(y-dropy <
range) && Math.abs(z-dropz < range))
{
      Dropper.write(180);
      Sleep(2);
      Dropper.write(0);
```

FIG. 1: Code which would be inserted into the main duty cycle would actuate the hatch servo, releasing a payload at the appropriate time. Using kinematics expressions, Ardupilot can calculate when to drop the package.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Constructing a T-shirt Cannon

BY **TY GILHULY, HARRISON KALT AND ALEX OBERFELD**

A look into the mechanics and construction behind a T-shirt cannon and how to achieve maximum efficiency through modification.

At the request of the Harvard Westlake Fanatics, we decided to construct a T-shirt cannon for sporting events. Using this T-shirt cannon, we plan on using our combined knowledge of projectile motion to find a couple of unknowns. These unknowns include but are not limited to: the least amount of pressure needed to successfully launch the t-shirt our desired distance of 20-30 yards, the maximum amount of air that the tank can hold, the maximum distance that the t-shirt can be launched, the optimal angle of incidence at which we should place our cannon in order to achieve maximum distance with a constant amount of pressure stored in the cannon. While we had initially planned to compare our air powered gun mechanism to one that utilized combustion, our air mechanism proved to be too faulty in its design. As a result, we have completely reconstructed our mechanism to improve efficiency. This new model is more compact and therefore contains fewer joints, allowing us to minimize the inevitable effects of air pressure leakage.

PROBLEM DESCRIPTION:

Our most glaring problem was the significant loss of pressure due to leaks. We identified the leaks by filling the gun with air and submerging it in water. The air bubbles allowed us to visually identify and patch up any leak with a layer of airtight silicon sealant. Another big problem that we encountered was that the sprinkler valve that we had purchased did not release all of the pressure stored up in the gun at once, but instead, only shot the projectile with a fraction of the pressure built up in the gun. To combat this problem we modified the valve in order to have a more complete pressure release.

ALEX OBERFELD

FIG. 1: Actual T-Shirt Gun

We drilled a small hole in the top of the chamber in the valve, allowing the air to bypass thesmaller hole that has been sealed with the same silicon sealant, resulting in an increase in pressure when the air streams through the newly created hole as there is an inverse relationship between pressure and area. Using the equation, $P = FA$, with P representing pressure, F representing force and A representing area, we can see that as the area of the hole decreases, there is an increase in pressure.

PROPOSED SOLUTION:

Due to these issues, we created another gun with some slight modifications. We again used a tire valve in order to fill up the gun but this time, constructed the joint with less connecting pieces in order to reduce pressure loss. The air then flows into the main storage tank where it is stored until firing. The main difference in this gun is the firing mechanism. Because we drilled an extra hole in our release valve and sealed the original hole, the gun empties more completely after every fire and shoots shirts farther. The one drawback to this design is that you must fill up the gun after every shot, unlike our original model. But, we have found that this newer model is more efficient and shoots farther.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Speech Acoustics as an Indicator of Athletic Performance in High-Pressure Situations

BY **ROBBIE LOEB**

Is there a way to predict how an athlete will perform in the clutch? In this project, I take a brief look at how an athlete's speech patterns could be an indicator of performance.

PURPOSE

In this project, I explore the connection between an athlete's speech patterns (intensity, pitch, frequency) before a game and their success in the clutch situations in that game.

METHOD

Pre-game specimen:

I record one-minute samples of athletes responding to an open-ended question using a headset microphone approximately two inches from their mouths to gather data on their speech patterns from before games.

Game statistics specimen:

I gather statistics for the subjects at the end of close games to be analyzed with the pre- and post-game specimens.

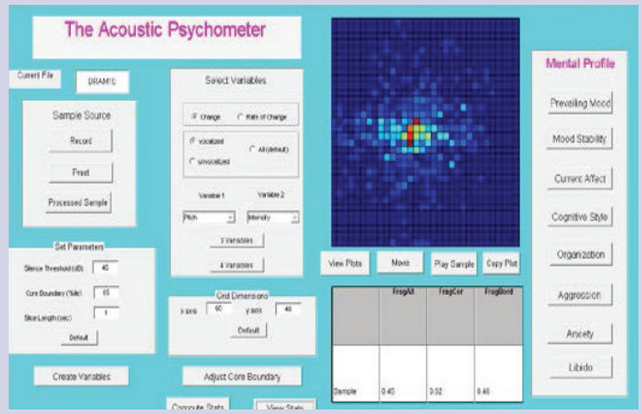
Post-game specimen:

I record speech specimens after the game from the athletes who logged stats at the end of the games, and compare that specimen with the pre-game specimen.

Data Definitions:

The defined "high-pressure situation" for volleyball is a serving point after the 20th point in which the teams are within three or four. Serving specialists are a separate group. Grade based on make/miss, how good of a pass the opponent made off their serve [0(ace), 1, 2, 3]. Each will be weighted in some way.

Data Analysis:



ROBBIE LOEB

FIG. 1: The stats are mean, standard deviation, skew, kurtosis of each variable and the covariance of two variables.

I match the athletes' performances in pre-defined "high-pressure situations" with their recordings and analyze the data in search of a correlation, comparing the success variable with the speech variable.

Exploratory Phase:

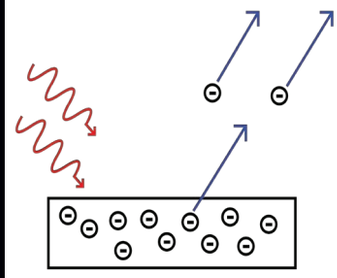
I explore which acoustic structures predict success in high-pressure situations by inspection of acoustic structures displayed graphically and inspection of the measurements of acoustic structures. Select variables include change, rate of change, vocalized and unvocalized sounds, pitch, frequency and intensity.

RESULTS

Due to time constraints during and after the boys' volleyball spring season, I was unable to gather sufficient data to be analyzed. With these data at hand and the analyzing program, the Acoustic Psychometer may predict how an athlete's speech patterns could be an indicator of performance.

STUDIES IN SCIENTIFIC RESEARCH PROJECT

Response of Static Surface Charges to the Photoelectric Effect



BY **MICHAEL ZAKS**

The relationship between the static surface charges that accumulate on a conductor in a flowing circuit and the photoelectric effect is investigated.

In this experiment, we will attempt to determine whether the surface electrons are more easily excitable in a circuit than they are when not in a circuit and attempt to quantify this relationship. I hypothesize that surface electrons in a flowing circuit will be more easily ejected from their respective metals.

CONCEPTS

Static Surface Charges

When current flows through a conductive material (in this case, a wire), surface electric charges accumulate on the wire. The importance charges, which have been of enormous interest to researchers, however, has largely been underappreciated .

Most introductory physics courses even neglect to mention the relationship between electrostatics and circuits, treating them as two completely separate topics. In fact, it is these charges that keep a circuit flowing in a controlled manner. In general, this distribution of surface charge densities is non-uniform and functions to maintain the potential around the circuit, to provide the electric field in the space outside the conductors, and to assure the confined flow of current .

The Photoelectric Effect

The photoelectric effect describes the tendency of electrons to be ejected from a substance by incident electromagnetic radiation of sufficient energy. The electromagnetic radiation's energy can be quantified using Planck's relation: E=hf, where h is Planck's constant and f is the frequency of the radiation. However, this energy must be sufficient to excite the electrons enough to eject them; this energy varies from substance to substance and is known as the Work Function (φ). The electrons emitted are known as photoelectrons since it is the light (hence, "photo-") that excited the electrons to be emitted.

EXPERIMENT

In this experiment, we will compare the effect of shining UV light on silver in a flowing circuit versus shining UV light on silver in a non-flowing circuit. We will measure this effect using a voltmeter. If we see a larger voltage drop in the silver of the flowing circuit than in the silver of the non-flowing circuit, my hypothesis will have been confirmed, and surface electrons in a flowing circuit will be proven to have a higher tendency to be emitted from their respective metals.

We will record the results in data tables for varying currents to see how and if the current affects the voltage drop, and by extension, the excitability of the surface electron. We will vary current by using resistors with different resistances.

POSSIBLE COMPLICATIONS AND CONCLUSION

Unfortunately, the experiment has not gone according to plan. With a largely theoretical physics concept such as the photoelectric effect, applying it and finding definitive physical results can sometimes be a challenge.

I am both hopeful and confident that superior equipment and better preparation will lead to exciting discoveries in the little-explored field of static surface charges.

Summer Internships

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


NATHANSON'S

The Whitehead Institute for Biomedical Research, with Dr. Hidde Ploegh
Allen Nikka '13
"I helped compile an index of Alpaca VHH nanobodies (antibodies) for use in further research, which would be ideal for experimentation due to their extremely small size. "


NATHANSON'S

USC Department of Biological Sciences with Professor Matthew Dean
Divya Siddarth '14
"I tested whether the Algerian mouse *M. spretus* carried alleles from the Western European house mouse, *M. m. domesticus*. I also used sequence alignment and management in BioEdit to determine whether introgressive hybridization had occurred."


NATHANSON'S

UCLA Laboratory of Neuroendocrinology & Avian Biology with Dr. Barney Schlinger
Taleen Mahseredjian '14
"I learned how to perform some PCR's and do experiments involving cDNA, along with multiple microanalyses and behavioral testing of scrub jays, as well as dissecting and mounting scrub jay brains onto slides, all of which helped us analyze the possibilities of manipulating this DNA."


NATHANSON'S

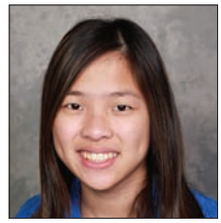
Technion: Israel's Institute of Technology
Eden Weizman '13
"My partner and I developed a new game called "Link Chess." I then developed a computer program served as an artificially intelligent opponent to play against. I presented our research in front of a panel of Technion's scientific faculty members and won first place."


NATHANSON'S

Cahill Center for Astronomy and Astrophysics, Adaptive Optics Lab at Caltech
Arianna Lanz '13
"My adviser is building a Transient Object Classifier called the "SED Machine" to operate on the 60-inch telescope at the Palomar Observatory. I build a spectrograph for the machine, and then use it to observe how temperature-sensitive different light sources were when doing wavelength calibrations."


NATHANSON'S

Bronner-Fraser Lab at Caltech with Ankur Saxena, Post-doc
Mane Williams '14
"Using a variety of techniques, we analyzed the movement of Zebrafish embryo neural crest cells and track their differentiation."


NATHANSON'S

USC Department of Molecular and Computational Biology with Professor Ian Ehrenreich
Irene Kao '14
"I worked on a project that studied the genetics of invasive growth in yeast, specifically looking at the environment's impact on invasive growth."


NATHANSON'S

UCLA
Jonathan Heckerman '15
"I wrote an iPhone app that monitors household appliances over a local network. The application helps users decide which devices to turn off in order to save the most energy."


NATHANSON'S

UCLA School of Public Health with Dr. Robert Schiestl and grad student Aaron Chapman
Ana Scuric '13
We worked on experiments examining DNA damage mostly from lung cancer patients by doing Gamma H2AX assays.


NATHANSON'S

USC, Sampath Lab at Zilkha Neurogenetic Institute
Greg Lehrhoff '14
"I helped design and program a new scientific instrument to measure the threshold of vision in mice."


NATHANSON'S

UCLA Medical Center with Dr. Gerry Lipshutz
Sarah Novicoff '14
"I researched potential gene therapies for liver disorders. The lab recently published a paper in a peer-review journal titled "AAV-based gene therapy prevents neuropathology and results in normal cognitive development in the hyperargininemic mouse," on which I was listed as a co-author."