CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

Delfin A. Acosta

Project Number

S1801

Project Title

The Effects of Gases on Solar Water Heaters

Abstract

Objectives/Goals

This experiment is designed to test whether changing the gases inside of the heating box will affect the amount of the time needed to heat the water to a given temperature. My hypothesis was that the gas with the lowest thermal conductivity would result in the most efficient operation of the solar heater. This is because it would prevent heat from escaping from the hot metal plate, through the gas and outside via the walls or conductive, metal valves.

Methods/Materials

The experimental water heater is designed like most solar water heaters; a plastic or glass top, a box that is air-tight, with copper pipes and a heat plate below to receive the energy let into the box and transfer it to the water. I tested to see the time taken by the water circulating in the heater to reach the temperature of 110 degrees Fahrenheit. In this experiment, regular air in the box was my control, then I filled it with various gases, and repeated the experiment. During each trial; I conducted three trials for each test group (Air, Argon, Helium); I measured out exactly the same volume of water at 70 degrees Fahrenheit. The room temperature outside the heater was kept at a constant 75 degrees Fahrenheit. In order to place the other gases, such as helium, inside the chamber, I installed two gas valves on either end of the container. The energy entering the heater was kept constant by utilizing two 250 Watt heating lamps kept at a distance of 1.5 feet.

Results

The results of my experiment were such that the air group was the most efficient, with an average time of 73 minutes. This was followed by Argon with a time of 74 minutes average, though there was an extraneous result, excluding this extraneous, the average is 76 minutes. Helium was the least efficient with an average time taken to reach 110F of 84.6 minutes.

Conclusions/Discussion

In evaluating my results and comparing them to my hypothesis, I found that my predictions were only correct with the Helium group, with it being the least efficient. The most efficient group, contrary to its thermal conductivity, was air, closely followed by argon. Yet, the difference between the times for the argon group and that of air, lie well within a reasonable margin of error. Thus, only another experiment, with more precise measurement, more sheltered from outside variables, can prove or disprove my hypothesis.

Summary Statement

To determine whether placing different gases with differing thermal conductivities inside the chamber of a solar water heater would affect its efficiency.

Help Received

Help from my father in welding together pipes.

Name(s)

Azra Azvar; Breanna Jones; Samantha Martinez

Project Number

S1802

Project Title

Biomimicry: The Effects of the Lotus Effect in Designing Nanoscale Surfaces in Products

Abstract

Objectives/Goals
We wondered if nanoscaled surfaced coat would benefit in design is we destructively tested plants exhibiting hydrophobic tendencies (e.g. the lotus effect).

Methods/Materials
A water/stain material resistant nanoscale surface engineered lab coat and several plants exhibiting the lotus effect were tested using common household products (i.e. ketchup, milk, ect.).

Results
We tested several plants exhibiting the same lotus effect as the lab coat to see if this biomimicry could aid scientists and engineers in designing more effective nanoscaled surfaced products.

Conclusions/Discussion
We found that the nanoscale surfaced lab coat was impervious to most common household substances after one washing. However it appears the motor oil destroyed the lotus effect on the engineered surfaces even after bleaching. We found that our plant surrogates effectively predicted this shortcoming.

Summary Statement

Biomimicry can be effectively used to design products.

Help Received

Mr. Gaughen's Nanotechnology A class taught us the basics of nanoscience; Adopted 'Lotus Effect' protocol in National Science Teacher's Association (NSTA); 'Nanoscale Science' (2007) pages 61-76.

Name(s)	Project Number
Namrata R. Balasingam	**S1803**

Project Title

Murray's Principle of Minimum Work and the Biomimetic Design of Efficient Microfluidic Networks for Tissue Engineering

Abstract

Objectives/Goals
The loss of organs due to disease or injury is a major medical problem, and often this problem can be corrected using organ transplantations. Since there is a chronic shortage of suitable organ donors, tissue engineering is being researched as an alternative source of transplantable organs. One major challenge facing this rapidly growing field is the optimal design of artificial vessels that can efficiently convey nutrients and waste across growing pieces of tissue. These artificial vessel systems consist of branching networks of microfluidic channels, whose dimensions vary from tens, to hundreds of micrometers. There is a close resemblance between these artificial constructs and the branching structure of blood vessels in mammals. This has prompted some researchers to propose that Murray's Law, which governs the bifurcation geometry of vessels in the mammalian circulatory system, be applied to the design of artificial vasculature.

Murray's Law predicts that flow rate through a bifurcating network is maximized when the diameters of the daughter vessels taper down from that of the parent vessel by the cube-root-of-two. This law applies only to vessels with circular cross-sections. Our objective is to generalize this result to realistic rectangular channel cross-sections that distinguish artificially constructed vessels from naturally occurring vessels that have circular cross-sections.

Methods/Materials
In my work, I have used the correspondence between Ohm's Law for current flow, and the Hagen-Poiseuille Law for fluid flow to derive formulas for the overall conductance of branching fluid-conveying networks. I wrote a small program that swept the geometric factors over a range of values, and looked for peaks in the conductance.

Results
There were three key findings in my work: (1) when the rectangular channels are strictly square, the tapering rules are exactly the same as those predicted by Murray for circular channels, (2) for more general rectangular networks I showed that the taper factor that maximizes the hydraulic conductance of a bifurcation is a function of the aspect ratio of the parent channel, and (3) for higher-order networks, I showed that the conductance is a sharply peaked function of the taper factor.

Conclusions/Discussion
I generalized Murray's Principle which applies to bifurcating channel networks of circular cross-section to artificial rectangular channel networks.

Summary Statement

I showed that the conductance of a microfluidic network of a given volume can be maximized by the proper selection of geometric scale factors.

Help Received

Name(s)	Project Number
Abrar Choudhury	**S1804**

Project Title

Developing a Novel Method to Decontaminate dSph Data for M31 Mass Estimation

Abstract

Objectives/Goals

Many galaxies have smaller satellite galaxies orbiting around them, known as dwarf spheroidal galaxies (dSphs). The goal of the research was to use fifteen dSphs of the Andromeda galaxy (M31) to calculate the mass of Andromeda. More accurately calculating Andromeda's mass is necessary to better model and understand our Universe. I hypothesized that this would be possible since the gravitational force of Andromeda on these dSphs corresponds with Andromeda's mass.

Methods/Materials

To use the dSphs to find the properties of Andromeda, the dSph data sets first needed to be decontaminated by eliminating foreground and background stars that were not part of each dSph. I developed a novel decontamination method using the stars' velocities, metallicities, and distances from each dSph. After determining which stars were members of the dSphs, I calculated the dSphs' velocity properties. By setting the centripetal acceleration of the dSphs equal to Andromeda's gravitational force, I was able to use the velocity properties to calculate Andromeda's mass.

Results

I calculated Andromeda's mass to be $6.78*10^{11}$ solar masses. I also used stars from Andromeda's halo as gravitational tracers to calculate Andromeda's mass. The mass calculated with the latter technique was $7.61*10^{11}$ solar masses.

Conclusions/Discussion

The data decontamination method I developed successfully removed a vast majority of the contaminants in the dSph data sets. The velocity properties calculated using the method correspond well with older results for the six previously studied dSphs. Also, the successful mass calculation conclusively proves that my hypothesis was supported. Because no other comprehensive method exists for decontaminating dSph data sets, my method has already been used by fellow researchers, and will be critical for all future studies of dSphs. The mass I calculated is corroborated by the mass determined from the halo stars, which was calculated for the first time in this research. Furthermore, my mass estimate is a factor of two smaller than the previous mass estimate. However, my data sets are newer, more comprehensive, and come from more optimally located dwarf galaxies. Future steps may include calculating the dark matter content of the dSphs or analyzing their chemical properties.

Summary Statement

I calculated a more accurate estimate for the Andromeda galaxy's mass with Andromeda's satellite galaxies by using a novel decontamination method that I developed.

Help Received

Dr. Guhathakurta mentored me, provided me with the data, and vetted my scientific procedures.

Name(s)	**Project Number**
Brittany File; Parker Levinson	**S1805**

Project Title

The Notion of Motion

Abstract

Objectives/Goals

Our objective was to discover how the varying radius of a softball pitcher#s arm affects the angular momentum of that particular pitch.

Methods/Materials

We conducted our experiment by filming five different softball pitchers as they threw various pitches and then reviewing the pitches in an iMovie editing program to calculate the exact time of the pitcher#s arm circle, before converting into radians/seconds (angular velocity). All data was recorded into a spreadsheet where the radius, which was measured from their shoulder to the middle of their palm, was also recorded. To calculate the rotational inertia, we massed a softball and used the measured radius from a particular pitch as our changing variable.

Results

After carefully evaluating the data, we discovered that as the rotational inertia increased, so did the angular momentum; the riseball had the smallest radius (.5363m) and the least angular momentum at (.8517 N*m/s) while the fastball had the greatest radius (.6066m) along with the greatest angular momentum (1.168 N*m/s). The trend found was that as the radius increases, so does the angular momentum.

Conclusions/Discussion

After looking over the angular momentum equation, it became clear that the angular velocity generally remained a constant; therefore, the rotational inertia was the changing factor in the equation. For angular momentum to be conserved, the angular velocity must also be a changing variable; however, in this case the pitcher was providing the constant external force (what we used as angular velocity) which allowed for no vacillation in number. Because the softball#s mass was also a constant, the radius was the major fluctuating variable. This allowed us to prove that by increasing the radius of a pitcher#s arm motion, the angular momentum would also increase. We also learned that though the angular momentum equation is a widely accepted and trusted method of calculation, it might not be the correct equation to apply to this particular type of physical motion. While we didn#t identify a better or more accurate equation to apply to the pitching motion, we take heart because we#re sure it took Isaac Newton many years and many tries to perfect his laws of motion.

Summary Statement

The purpose of this experiment was to determine how angular momentum affected different pitches in softball by directly applying the principles of physics to live pitching.

Help Received

Pitchers helped by volunteering their time to participate in the experiment; Physics teacher helped solidify conceptual elements of the experiment.

Name(s)

Austin Ha; Alan Yoon

Project Number

S1807

Project Title

Waves of Sound to Wash Out the Flames

Abstract

Objectives/Goals

The objective of this experiment was to find what frequency of sound best extinguishes fire at two different volume levels of -15 dB and 6 dB, both at 25% speaker output from a subwoofer. Our hypothesis was that a frequency of 20 Hz would best extinguish a small, half inch flame from a distance of six inches away from the subwoofer. Accordingly, higher frequencies would not be as effective. Also, the louder volume will be more effective than the quieter volume.

Methods/Materials

165 candles were used in this experiment. One candle at a time was lit and placed six inches away from the center of the subwoofer. The subwoofer played a single frequency, which was set by the laptop on Logic Pro, for three seconds at -15 dB. Using the video camera, the point at which the flame was deflected the furthest was recorded. Then, the frequency was replayed at 6 dB and the process repeated. This process was repeated for each frequency from 20 Hz to 120 Hz in intervals of 10 Hz.

Results

In the resulting averages, the frequencies around the middle of the tested spectrum (around 90 Hz) were the most effective. The general effectiveness of the sound exponentially decreased around the low and high range of frequencies tested. All frequencies performed better at the higher volume.

Conclusions/Discussion

The main hypothesis was that lower frequencies and higher volumes would be able to extinguish flames more effectively than higher frequencies and lower volumes. The middle frequencies performed the best, refuting part of the hypothesis, but the higher volumes were more effective than lower volumes, supporting part of the hypothesis. Our experiment presents an alternative method of fire-extinguishing that can be used especially in micro-gravity situations where water and chemicals would not effectively douse flames.

Summary Statement

This project tests the ability of different frequencies of sound from a subwoofer to extinguish a fire.

Help Received

Mr. Yoon helped finalize the project name; Mrs. Ha provided tape and food during work.

Name(s)

Chiyoung Kim

Project Title

Three's a Crowd: An Investigation of the Absence of an Asymmetric, Stable Three-Body System

Abstract

Objectives/Goals
Except for figure-eight systems, trinary stars that are non-hierarchical and stable are extremely rare, or do not exist, as they have currently not been observed. This research investigated the cause for such an absence of these systems.

Methods/Materials
A simulation attempting to simulate and cover as many possible three-body systems was set up to find stable, non-hierarchical orbits.

Results
The bodies either collided or flew off, resulting in an unstable system. There were, however, systems in which one star escaped and the final two stars orbited around each other, approximating a two-body orbit as the third body flew farther and farther away, i.e. becoming a hierarchical system. Some cases, however, showed a stable orbit between three bodies for the time period of three years.

Conclusions/Discussion
The results show that only in very special cases does this happen, while most configurations lead to unstable orbits. Because the research looked for cases that may occur in nature, the special cases found in this research are cases that are important in theory but not for practical applications.

Summary Statement

The project investigates a special case of the three-body problem and describes the results and the trivial stable orbits.

Help Received

Dr. James Choi helped me debug the code when I could not find the source of the error.

Name(s)	Project Number
Jeremy Kwak; James Yoon	**S1809**

Project Title

The Effect of Different Cup Holders on the Cooling Rate of Hot Black Coffee

Abstract

Objectives/Goals
To find efficiency of different kinds of cup holders depending on their volume of air pockets

Methods/Materials
Part I: Preparation for the experiment
Gather materials:
Paper cup
Metric measuring cup
Metric ruler
Electronic thermometer(Xplorer PASPort)
Cup holders(Peet¡#s Coffee&Tea, Starbucks, The Coffee Bean, Panera)

Part II: Testing the cup holders
1. The coffee was boiled to 68.0¡É
2. Using the metric measuring cup, 200mL of coffee was poured to the paper cup with cup holder(Peet¡#s Coffee&Tea)
3. Temperature of coffee was measured every minute for 10 minutes
4. The steps were repeated for other cup holders

Part III: Measuring the volume of air in air pockets
1. The volume of the air pockets had a cylinder shape; height and radius were measured

2. . The volume of the air pockets were found by the formula (¥dr2h), then divided by 2(Exception: Peet¡#s Coffee&Tea, Panera)
3. The volume of the air pockets were then multiplies by the number of the air pockets

Results
The volume of air in the air pockets greatly affected the cooling rate.
The cup holder with greater volume of air in air pockets had low cooling rate
Important data values: average deviation, percent deviation, reported value

Conclusions/Discussion
The hypothesis was correct that the most efficient cup holder will have more volume of air in the air pocket.

Summary Statement

The most efficient cup holder had the most volume of air in the air pocket

Help Received

Name(s)	Project Number
Isfar Munir; Jamison Sloan	**S1810**

Project Title

The Effect of a Magnetic Field on the Plasma Arc of a Tesla Coil

Abstract

Objectives/Goals

The purpose of this project was to measure the degree to which a magnet deflects the plasma arc generated by a Tesla Coil (if any deflection occured at all). It was hypothesized that the magnets would have an effect on the arc, and that north and south poles would produce no signifigant change over each other. In addition, 2 magnets put together to form a rod was compared to 5 magnets put together to form a rod, with the hypothesis predicting that there would be no difference between the two.

Methods/Materials

A Tesla coil was constructed by hand for this project; a high voltage transformer, a capacitor rated for high voltages, tungsten rods (for the spark gap), an aluminum toroid, and copper wire were all used to construct the Tesla coil. The Tesla coil was powered through a standard wall outlet. A steel rod was screws into a wooden base. A steel hex nut was screwed onto the rod and the magnets were balanced on top of the nut (facing vertically). 2 neodymium magnets were put together for two set of trials, 5 magnets were put together for another two tests (north and south poles were both tested), and a control data set was taken without any magnets at all. For each trial, a camera atop of a wooden horse was used to take a picture for each trial. This pictures were put into Microsoft Paint, were (after scaling) a gridline was used to measure the maximum point away from the rod the arc reached.

Results

Statistical tests were run on the data sets to determine if the magnets had a significant effect on the path of the arc from the Tesla coil. F-Tests were run to determine variances between data sets, and for every F-Test a T-Test was also run. All data sets had equal variances (per the F-Test run on that set). Thus, all T-tests which were run assumed equal variances. The T-tests indicated that the magnets had no significant effect on the arc coming from the Tesla coil.

Conclusions/Discussion

This project refuted our hypothesis that the magnets would have an effect on the plasma arc of a Tesla Coil. This conclusion can be reached by looking at any statistical test conducted during the experiment. Future experimentation will focus on using stronger magnets and multiple magnets positioned in different locations to exert a deflection on the plasma arcs. This is a path not taken previously, and with luck the experiment can uncover the effects magnets have on high voltage electricity discharges.

Summary Statement

This project was designed to determine the effect of a magnetic on the path travelled by an arc coming from a Tesla Coil.

Help Received

Physics teacher assisted in determining the strength of the magnets; Our friends Isaac and Stephen assisted in the statistical analysis; our friend Karel assisted in winding the secondary coil

Name(s)	Project Number
Veronica Murashige; Laura Yu	**S1811**

Project Title

A Little Color to Lighten the World Up: Can We Increase Solar Cell Efficiency by Excluding Different Types of Light?

Abstract

Objectives/Goals
The goal is achieve the optimal amount of efficiency from harnessing solar radiation by altering which wavelengths of light in the electromagnetic spectrum are allowed to pass through the filters-therefore being absorbed by the solar cell and converted to clean, usable electricity.

Methods/Materials
Materials: 4 floppy disks, 5 Educational Solar Energy Kits (model 689), cellophane wrap in the colors primary blue, red, yellow, and clear, protractor, 2 Vernier LabQuest devices with portable chargers, 5 differential voltage probes, and a table with the height of 47 cm. Procedure: Make a series of silicon solar cells to form 5 panels composed of 4 cells each. Cover all with 2 filters that are specified from cell to cell that allow only certain light through to be absorbed. The independent variable is the type of filter: red and blue to let through yellow light, clear-clear to be the control, floppy-disk filters to only let infrared through, yellow-blue to let wavelengths that make up red light, and red-yellow to allow blue light to pass through by reflecting red and yellow light. The panels are wired to differential voltage probes to measure the direct current (DC) of the conversion of solar energy to electrical measured in volts (the dependent variable). On a sunny day, the experimenters took measurements for about two hours in 75 degrees Fahrenheit weather. Multiple sample trials were taken, prior to the experiment run consisting of 32 trials, to test if the solar panels are active. Then record the statistical mean for each of the 5 solar panels for 32 one min. intervals.

Results
Panel A covered by two clear filters results in the largest voltage output. Panel F covered by red and blue filters was the next highes, and Panel B, covered by yellow and red filters follow suit. The fourth best was Panel E, covered by yellow and blue filters. Panel D, covered by and infrared filter and a clear filter, had the least electrical output.

Conclusions/Discussion
The hypothesis is invalid possibly because the filters were too thick and varied in density, the solar cells were not sensitive enough or were too old, or the exclusion of other forms of radiation decreases the absorption of solar energy therefore decreasing electrical output.

Summary Statement

Infrared, clear, and colored filters were used to determine if excluding certain wavelengths of light increase silicon solar cell efficiency.

Help Received

The Milspec Heat-Treating Company for heating the silicon wafers to 1933 degrees Fahrenheit. Mrs. Wagner for the Solar Energy Kits, use of Lab Quest devices and Differential Lab Probes. Mr. Pittman for the solar panels. Laura Yu#s dad for making the stand/backing for the display board.

Name(s)

Jason Qu

Project Number

S1812

Project Title

Testing and Calibrating an Off-plane Diffraction Mount for Soft X-ray Analysis

Abstract

Objectives/Goals

The goal of this project is to modify and make use of a diffraction grating Belly Band with the original purpose of mounting and calibrating diffraction gratings, which focuses X-rays onto a CCD in a very precise arc for image analysis. If successful, this device may be used as part of an actual sub-orbital rocket payload to collect images of X-rays for analysis in launches. Off-plane diffraction gratings have been used in X-ray spectrometers on the sub-orbital rockets in the NASA missions CyXESS and EXOS, successfully capturing high-resolution data from soft (low-energy) X-rays originating from supernova remnants in the Cygnus Loop.

Methods/Materials

First I decided the appropriate substitutions to be made for each component, and designed, built, and set up the experiment. Then to insure the best result, I had to develop a quick algorithm for collecting, analyzing, and interpreting the data, as by the virtue of the experiment, real-time feedback was of the utmost importance.

Results

Using a 3D histogram, I found that the Belly Band was an accurate grating mount to an accuracy of 2-3 pixels, a tolerance of only 0.019## on the angle of the grating, well within our 5## goal. We found that the Belly Band was not an effective precise grating calibrater, because even the tiny 1/256 inch set screws were too cumbersome for this design.

Conclusions/Discussion

In this experiment, I developed methods and algorithms that set a precedence and foundation for future, follow-up experiments to fine-tune the Belly Band. Furthermore, I proved that the concept of this experiment is viable, and once this Belly Band is fully fine-tuned it will be integrated on an actual suborbital#s payload scheduled to launch within the next two years.

Summary Statement

To improve a device called the Belly Band, for mounting and positioning diffraction gratings, which can be used to align and focus incoming X-rays to look at the stars, constellations, and even supernova remnants.

Help Received

Used lab equipment in Belin-Bank Center at University of Iowa

Name(s)

Jeremy P. Rudd

Project Number

S1813

Project Title

Laser Induced Fluorescence

Abstract

Objectives/Goals

to find the wavelength that chromium 3+, alumina, and neodymium fluoresce at in different concentrations in pure glass. Also to find the cause of the green glow observed in the paperweights when a violet laser was shown through them.

Methods/Materials

PROCEDURE (TESTS)

1. mount lasers to heat sinks (to prevent overheating)
2. make an optic table (magnetic to keep lasers from moving)
3. in a dark room, shine laser through glass samples and measure fluorescence with spectrometer

MATERIALS

glass frit

lasers

spectrometer

chromium 3+

ruby

neodymiun

alumina

PROCEDURE (GLASSES)

1. measure out 10 grams of glass frit into mixing dish
2. add correct amount of dopant to the glass frit
3. add water to mixture and mix
4. let mixture of glass frit, dopant, and water dry
5. put mixture in crucible and put in furnace for 10 minutes at 900°C
6. take glass out of crucible and let cool

Results

the chromium and alumina did not fluoresce and the neodymium samples fluoresced infrared.

Conclusions/Discussion

The rubies fluoresced at slightly different wavelengths, but the surprising part of the experiment was that the chromium and alumina glasses showed no fluorescence. The neodymium glasses did fluoresce in the infrared and were seen from a camera only and not testable with the spectrometer. the green glow in the paperweight was possibly from small amounts of uranium in the glass, called vaseline glass.

Summary Statement

finding the differences in fluorescence in samples doped with different amounts of dopants.

Help Received

used furnace at Spectra Mat inc. under supervision of Gregory Rudd (father)

Name(s)	**Project Number**
Andrew J. Smith	**S1814**

Project Title

Protection with Geometry

Abstract

Objectives/Goals

My objective was to determine what the optimal angle of metal is for tank armor. Out of five selected angles ranging from ninety degrees vertically to thirty degrees. I believed that thirty degrees would work the best since it is closest to parallel with the ground.

Methods/Materials

Five different angles ranging from 90 degrees to 30 degrees were tested three times each, on thin metal "flashing" shingles measured in sheets; one sheet each in this test. An air cannon was constructed using Schedule 40 PVC pipe parts and air compressor adapters, with an electronically activated sprinkler valve. The cannon fired a 1/2" bolt-like projectile at the flashing while being enclosed in a wooden box for safety; the cannon fired at 100 psi.

Results

All but the flashing at 30 degrees were fully penetrated consistently, the 30 degrees having an anomaly, which was one deflected shot. Using an equation found in research, I calculated the relative thickness of each piece of flashing at each degree I plugged in. The normal thickness was considered one, or one sheet of flashing. From the equation I found that 30 degrees relatively doubles the thickness of the piece of flashing.

Conclusions/Discussion

Further research and testing are still being done, but the results from the first experiment show that 30 degrees would seem to be the best angle, in theory. In practice, 30 degrees was the same as all the other angles aside from the single incident of deflection.

Summary Statement

This project hopes to expand the research on angled tank armor and perhaps prove its continued worth.

Help Received

Friend and Father helped with manual labor(direct construction of project i.e. use of power tools).

Name(s)

Debnil A. Sur

Project Number

S1815

Project Title

The Effect of Titanium Dioxide on Photovoltaic Cells

Abstract

Objectives/Goals

This experiment tests the effect of varying concentrations of titanium dioxide (TiO2) on the efficiency of photovoltaic solar cells. Though this chemical has shown to improve the efficiency of dye-based solar cells, it hasn#t been tested in the context of photovoltaic cells. Three variables will be tested: coating thickness, different types of light, and angle of light.

Methods/Materials

Six PV cells, solid TiO2, distilled water, and various light sources were used. Five concentrations of TiO2 were mixed; after initial measurements of output, cells were painted with different concentrations. They were then tested under different light sources and with varying angles. After washing off the cells, the output was again recorded under the different light sources. Three tests will be done to reduce variability, and data will be standardized by control values.

Results

TiO2 significantly boosted cell output across the light sources, posting increases as high as 39% in sunlight and 25% in UV; thus, efficiency was improved over the majority of usable light. While an optimal concentration was indeterminate, on the whole, higher concentrations of TiO2 led to better output; 1 mg/mL seemed to have the most consistent results, though. However, the data collected did not display any clear relationship between TiO2 and output at different angles, so that effect is indeterminate.

Conclusions/Discussion

Titanium dioxide clearly had a beneficial effect on photovoltaic cell output; at the same time, though, a few additional experiments need to be conducted for larger success. First, more testing should be done to determine TiO2#s effect on different angles. Additionally, an optimum concentration should be determined through more detailed testing. Finally, long-term tests should be done of output to determine whether TiO2 has a corrosive effect. Through these additional tests, hopefully, TiO2 can be used on a larger scale; these experiments clearly demonstrate that it could have enormous implications for photovoltaic cells.

Summary Statement

I tested the effect of a titanium dioxide coating on photovoltaic cell output, varying coating thickness, type of light, and angle of light.

Help Received

Dr. Youssef Ishmail supervised lab equipment use; my family constantly supported me and helped with my board

Name(s)

Connor E. Tom

Project Number

S1816

Project Title

Using the Temperature Dependence of the Speed of Sound to Detect Volatile Organic Compounds in Air

Abstract

Objectives/Goals

The goal was to determine whether or not the temperature dependence of the speed of sound in air with harmful concentrations of volatile organic compounds (VOC's) would deviate enough from the predictions of the ideal gas law in order to make an effective and low-cost acoustic VOC sensor. Current VOC sensors based on photo-ionization are very sensitive but costly and therefore deployed mostly in industrial and laboratory environments. A low-cost sensor could be installed in every home and workplace to monitor indoor air quality.

Methods/Materials

The speed of sound was measured by measuring the resonant sound frequency in a closed tube. The tube was made with PVC, could be opened for cleaning, and had valves for insertion of gases and liquids. A speaker, microphone, and thermocouple were placed in the tube through holes sealed with epoxy. The speaker was driven by a precision sine wave generator. The microphone signal amplitude was detected using a laptop and the program Audacity. The resonant frequency (frequency of peak amplitude) was determined to 4 digits by averaging the frequency on the low and high frequency side of resonance at ~80% peak amplitude. The temperature was varied between -20^oC to +20^oC, by placing the resonant tube in the freezer section of a refrigerator and read out using the thermocouple to 0.1^oC. The gas mixture in the structure was varied by loading with clean air at -20^oC and then inserting small volumes of liquid VOC's: acetone and n-butane.

Results

The resonant frequency of the tube is linearly proportional to the velocity of sound and inversely proportional to the length of the tube. Allowing for the linear thermal expansion coefficient for PVC (published coefficient), the temperature dependence of the velocity of sound for clean air was nearly ideal with Sqrt(T) dependence. Air with VOC's showed additional temperature dependence that could be distinguished from ideal. The experimental accuracy and systematic uncertainties for this setup were estimated.

Conclusions/Discussion

Results suggest that with an improved experimental setup, it may be possible to make a VOC detector at the 1000 ppm level using the temperature dependence of the speed of sound. This range can be relevant to human safety: the ST (short term) OSHA PEL (Permissable Exposure Limit) for acetone is 1000 ppm.

Summary Statement

Experiments were conducted to measure the temperature dependence of the speed of sound in VOC-air mixtures and suggest that a low-cost acoustic sensor could be made with 1000 ppm sensitivity.

Help Received

Name(s)

William Xue

Project Number

S1817

Project Title

Nondestructive Corrosion Detection in RC Using Heat Induction and IR Thermography

Abstract

Objectives/Goals
To monitor and assess corrosion in the aging civil infrastructure, we proposed integrated heat induction and IR thermography technology to detect corrosion in steel reinforced concrete. This project aims to evaluate the feasibility of the proposed method and study the thermal and electromagnetic characteristics of corrosion in response to the inductive heating.

Methods/Materials
An inductive heater was employed to remotely heat the steel rebar from the concrete surface, and an IR camera was applied to measure IR intensity at the concrete surface. Bare rebars and RC specimens with different cover depths were fabricated and induced with different levels of corrosion through an accelerated corrosion process. The IR thermographs were recorded during heating and cooling periods.

Results
From the bare rebar tests, the peak IR intensity depends on the amount of corrosion in the rebar; the more corroded rebar exhibited faster heating and cooling rates. From the RC specimen tests, the corroded rebars had a higher IR intensity on RC surface than the non-corroded ones. The heating rate in the corroded RC was also higher. As the concrete cover depth increased, however, it became less efficient to heat the rebar and more difficult to identify the difference between corroded and non-corroded specimens using the IR camera.

Conclusions/Discussion
Experiments on the bare rebars and RC concrete specimens were conducted using an inductive heater and IR thermography. Increases in the electrical resistivity and magnetic relative permittivity due to rust make the corroded rebar more sensitive to inductive heating. The peak IR intensity and heating rates strongly correlate to the corrosion level. This study demonstrates a potential application of the integration of heat induction and IR thermography for the nondestructive detection of rebar corrosion in concrete structures.

Summary Statement

This study demonstrates a novel application of heat induction and IR themography for the nondestructive detection of rebar corrosion in concrete using the thermal and electromagnetic characteristics of rust

Help Received

Used lab equipment at University of California, Irvine under the supervision of Dr. Maria Feng

Name(s)

Sara K. Simpson

Project Number

S1899

Project Title

Neuronal Nonlinear Dynamics: From an Optical Illusion to Parkinson's Disease

Abstract

Objectives/Goals

This project applied a novel physical framework of perception, based on modeling neurons as nonlinear oscillators. The objective was to understand the underlying physical basis for the Continuous Wagon Wheel Illusion (C-WWI), the perceived switch in direction of repetitive motion under continuous illumination. Using the nonlinear dynamics of direction-selective neurons, I created equations for a neural-network model to be numerically solved on a computer to determine if they accurately reproduced published experimental data. Neurons were modeled as mutually-coupled, nonlinear phase oscillators, subject to excitatory stimuli and cortical inhibition, emphasizing common neural characteristics across different parts of the brain.

Methods/Materials

Computer simulations were conducted to determine if this model reproduced data on perception of the C-WWI and neural activity in observers during perception. The time-dependent phases of neurons in direction-selective clusters were numerically determined as a function of variables such as excitation strength of the stimulus, strength of the inhibition, and excitation and inhibition from other neurons. The resulting phases were then analyzed and graphed to determine the type and degree of synchronization between neurons.

Results

The computer simulations presented a wide range of nonlinear dynamics for the coupled neurons as a function of the input parameter values. Partial and full synchronization only between same-direction neuron clusters, or across neuron clusters, was observed for different parameter values. Significantly, switching between different clusters, representing perceptual switches, occurred with a probability consistent with published studies of the C-WWI.

Conclusions/Discussion

The model accurately simulated oscillatory temporal patterns of direction-selective neurons. The computed results also indicated that the model captured behavior of real direction-selective neurons. This was proved in two different ways: 1) the clear examples of perceptual switches and 2) the percentage of the time these perceptual switches occurred accurately reflected the frequency of their occurrence in data collected in previous studies. Further, neural synchronization without external stimulation, associated with Parkinsonian tremors, resulted from further variation in parameters, indicating broad applications in understanding brain function.

Summary Statement

Computer simulations showed that the mathematical equations I created employing nonlinear dynamics accurately described neural activity in situations ranging from perception of an optical illusion to muscle tremors of Parkinson#s Disease.

Help Received

Parents helped with board.