Name(s)
Ainesh Arumugam

Project Number
S0301

Project Title
Fabricating Suspended Carbon Microfibers for 3D Carbon Microelectromechanical Systems Using Nearfield Electrospinning

Abstract

Objectives/Goals
Carbon Microelectromechanical Systems (C-MEMS) are used in microfluidic applications and are theorized to be a suitable low cost replacement for today's silicon based electronics. The design goal was to develop a suspended carbon microfiber lattice for 3D C-MEMS using nearfield electrospinning that exhibits aligned behavior and has fibers that have a comparable diameter and spacing as produced through multilayer photolithography.

Methods/Materials
Polyacrylonitrile (PAN) polymer was dissolved in N-N-dimethylformamide (DMF) at 40 °C for 24 hours at a concentration of 9% PAN. This solution was loaded into a syringe and pumped at a flow rate of ~1.0 nL/min. 600 V was applied to the needle charging the polymer, and fibers were drawn onto a silicon wafer substrate placed on a grounded aluminum drum rotating at 2000 RPM placed approximately 1 mm from the needle. The syringe was moving laterally at a speed of 60 µm/sec along the edge of the drum. Electrospinning was done at 25.0% relative humidity. This process was repeated after rotating the substrate by 90° to get a lattice 3D shape. The PAN fibers were stabilized at 275 °C for 5 hours and then pyrolyzed with a constant nitrogen flow rate of 4600 ccm with a gradual increase of temperature up to 900 °C. By varying the RPM and voltage, it was possible to optimize the electrospinning process. The fiber diameter and spacing were measured using a light microscope and the structure was observed with scanning electron microscopy (SEM).

Results
The 3D fiber lattice had an average diameter of 1.1 µm and spacing of 5.7 µm. As the RPM increased, the diameter and the spacing of the fiber decreased to a minimum of 0.84 µm and 1.87 µm, respectively. However, past 2000 RPM, the fiber became discontinuous and lost its aligned state. Higher voltage gave coarse and bigger fibers, while lower voltage gave smooth and smaller fibers, with a minimum of 1.38 µm diameter. Below 600 V, the fiber lost its aligned state and began to curve. Voltage variations caused a negligible impact on spacing.

Conclusions/Discussion
The objective of this project was to electrospin a suspended carbon microfiber lattice for 3D C-MEMS with fibers that have a comparable diameter and spacing as those produced by multilayer photolithography. The 3D lattice's fibers had an average diameter of 1.1 µm and an average spacing of 5.7 µm, exhibited aligned and suspended behavior, fulfilling all design goals.

Summary Statement
I fabricated suspended carbon microfibers in a 3D lattice structure through electrospinning, a cheap and easily scalable process.

Help Received
Professor Marc Madou of UCI advised me on my project and assigned me a mentor, Derosh George, who helped me throughout the project. Mario Ramos of ITESM of Monterrey, Mexico, and Tuo Zhou of UCI trained me on how to perform near field electrospinning.

Name(s)
Ansel R. Austin

Project Number
S0302

Project Title
The Boxfish Advantage: A Novel Biomimetic AUV Design for Coral Habitat Research

Abstract

Objectives/Goals
Significant need exists to develop a submersible that will be able to meet research goals in the spatially complex and turbulent coral reef environments. Superior impact resistance, low drag coefficient, high hydrodynamic stability and maneuverability of Ostracion cubicus (yellow boxfish) point to the performance advantages stemming from the O.cubicus' unique structural adaptations, and as such should be incorporated into a specialized AUV for operating in boxfishes' native coral reef environments. I propose that coral reef research goals can be more successfully met by utilizing a novel AUV design, which leverages Ostracion cubicus' hydrodynamic adaptations. My engineering goal was to design the body of a specialized AUV for coral habitat research, which leverages unique hydrodynamic adaptations of Ostracion cubicus and performs within 15% or better of O.cubicus in the areas of drag (as characterized by drag coefficient, Cd) and stability (as characterized by turbulence intensity, TI).

Methods/Materials
I obtained a micro-CT scan of an Ostracion cubicus specimen; prepared a 3D model using Autodesk Inventor, Meshmixer, Mudbox, and Maya; designed 3 AUV iterations based on the O.cubicus scan; used Autodesk CFD to test the four models for drag coefficient (Cd) and turbulence intensity (TI), using O.cubicus as a control; recorded and analyzed the data to determine which AUV iteration(s) met my engineering goal; rapid-prototyped the two most successful AUV body iterations.

Results
CFD testing demonstrated the following in comparison to the O.cubicus control:
1) AUV_v.1: (close approximation of O.cubicus) Cd -26% TI -19%
2) AUV_v.2: (lower frontal surface profile) Cd + 22% TI +39%
3) AUV_v.3: (keel surface extended by 5%) Cd ± 0% TI +10%

Conclusions/Discussion
CFD data analysis suggests that it is possible to design an AUV body which not only meets, but exceeds the hydrodynamic performance of O.cubicus, as characterized by the drag coefficient and turbulence intensity. Testing demonstrated that closely approximating the O.cubicus' shape, as well as extending keel surface, produced the most hydrodynamically efficient AUV hulls. Two of the iterations met my engineering goal: AUV_v.1 and AUV_v.3 drag coefficient and turbulence intensity measurements were lower than or within 10% of Ostracion cubicus.

Summary Statement
I leveraged unique hydrodynamic adaptations of the yellow boxfish to design, CFD-test, and optimize the body of an AUV for coral reef research.

Help Received
I did all of the research, 3D design, CFD-testing, and rapid prototyping on my own, after Dr. Adam Summers (University of Washington) provided the Ostracion cubicus micro-CT scan and Dr. Stacy Farina (Harvard University) converted the CT stack into an STL file.

Name(s)
Michelle Boguslavsky

Project Number
S0303

Project Title
Liquefaction Affects the Settlements of the Lego Building Depending on the Type of Soil Mixture

Abstract

Objectives/Goals
Settlement of the Lego assembly building due to the Liquefaction phenomenon was investigated for the 3-different types of soil mixtures. Soil liquefaction is soil failure due to the varies static or cyclic load in closed proximity of the shallow ground water table. The purpose of this study was to identify what type of soil more susceptible to liquefaction.

Methods/Materials
Three types of soil were used in the research: clay; loamy /fill and sandy soil. Experimental shaking table was constructed out of plywood and wooden stick. To create violent shaking - electrical sander was attached to the table. Lego blocks were used to assembly structure to imitate building, supported by the soil. Three containers filled with 2 kilograms of different type of soil and added 0.7 liters of water were used in the 30 experimental trials. 10 Trails for each type of soil. Each soil container with Lego structure on top was placed on the shaking table and shake for 60 second, then settlements of the Lego assembly measured in millimeters was recorded for each trial.

Results
Sandy soil was fully liquified and Lego structure settlement data was about twice greater than in partially liquified loam /fill type of soil. The percentage of data deviation was very small for both type of sandy and loamy / fill soil, 5% and 8% respectively. Experimental study for the clay type of soil was shown significant percent of data deviation spread up to 57.8%. However, clay soil was never liquified during the shaking and apparently was not properly compacted prior to the experiment.

Conclusions/Discussion
Experimental data shown that clay soil has very low to none abilities to liquify. The loamy /fill and Sandy soil can be liquified due to liquefaction phenomenon. Both of those soils have low internal frictions between the soil particles and a lot of air voids, which could be filled with water and liquify the soil.

Summary Statement
I found that sandy soil was the most affected by liquefaction which resulted in my Lego building sinking with greater depths, the Loamy / fill soil was partially liquified and the clay soil did not liquefy at all.

Help Received
I designed the shaking table by myself while my father suprivised when I started to cut plywood and screw the table legs.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Joseph A. Cestone

Project Number
S0304

Project Title
Using Electrical Current to Strengthen Wire

Abstract

Objectives/Goals
The purpose of this experiment is to determine if conducting electricity in wire affects its metallic bonds and thus its tensile strength. It was hypothesized that if an electrical current were sent through a wire, then its tensile strength would be increased, because the voltage induces electron movement in the direction of the current, thereby aligning the metallic bonding along the length of the wire.

Methods/Materials
To test this theory, 30 gauge copper wire was tensioned with increasing force between a dual servo motor winch and a stationary clamp until tensile failure occurred, at which point the force required to break the wire was recorded. This experiment was performed 50 times: 25 times with 1.5 volts of power from a D-sized battery, and 25 times with no voltage.

Results
The wire with voltage averaged 7% stronger than the wire without voltage, when the batteries were fresh. Some trials had to be discarded due to loss of voltage in the battery. Calculated with the stalled torque of the motors and the radius of the winch, the maximum load of the wire was increased from 5.5 to 5.9 pounds.

Conclusions/Discussion
The results of the experiment supported the hypothesis that direct current can increase the strength of wire! This experiment demonstrates an easy way to manipulate metallic bonding to increase the strength and usefulness of wire, and its potential applications could be limitless!

Summary Statement
This project tested the tensile strength of copper wire with and without electrical current, and found that the current strengthened the wire.

Help Received
I designed, built and performed the experiments myself. My grandfather, a retired electrician, gave me advice with electricity. My parents, aunt and uncle gave me grammatical suggestions and corrections.

Name(s)
Brian Chen; Joever Orillosa

Project Number
S0305

Project Title
Tunnel Vision: Redesigning for Structural Efficiency

Abstract

Objectives/Goals
The goal of our project is to find a new tunnel lining design that is stronger, and more stable while being environmentally friendly by reducing the amount of materials that is required to produce this structure. By reducing the amount of materials used, we do not only help the environment, but also decrease the costs of making the tunnel. This is important because tunnels are used in a variety of ways, they are utilized for mining, transporting water, sewage, and gas. They are also being used for transportation purposes including subways, railways, highways, and even canals. Thus, any cost-saving measures could widely benefit national infrastructure.

Methods/Materials
We used a computer with AutoCAD to draw our various tunnel lining designs. Used the finite element analysis software AutoDesk In-CAD Nastran to simulate the tunnels in real life conditions. We utilized a 3D printer to print physical models of our tunnel designs to be used for testing using an Instron 3369 testing system.

Results
From the results, the normal circular tunnel was the most stable, however the hexagon tunnel and the octagonal design were the most environmentally friendly due to it having less mass, which means less materials are required to make the tunnel. The hexagon and octagon tunnel designs used 30% less materials than the current standard tunnel lining. We noticed that the hexagon tunnel design had the lowest mass, but was stronger than the octagonal design. This shows that the hexagon design is stronger while using less materials.

Conclusions/Discussion
After repeated numerous computer simulation trials with multiple models of our designs, it was revealed that the hexagon tunnel design used the least amount of materials, and was stronger than the octagon design. However, it was not as strong as the current standard tunnel design. It is concluded that although the hexagon design is not as strong as the current solid design, it could still be utilized in conditions where there are low stress and pressure.

Summary Statement
We attempted to redesign tunnel linings with a focus on strength and stability enhancement while reducing the amount of materials used. We discovered that our hexagon design used the least amount of materials while remaining strong.

Help Received
We designed and made the tunnels independently. We used the 3D printers at Eleanor Roosevelt High School under the supervision of Mrs. Graham to produce physical models of our designs. We then used the Instron 3369 testing system at UCR under the supervision of Mr. Rightnar to test the physical designs.

Name(s)
Ashwat Chidambaram

Project Number
S0306

Project Title
Maximizing Aerodynamic Efficiency through Dynamically Changing Airfoil Cambers

Abstract

Objectives/Goals
Airplanes are known for their constant innovations in efficiency. Scientists and engineers in the industry today are always pushing to discover new ways to produce the same output with reduced energy and fuel consumption. I sought out to find a way to make planes fly more efficiently through innovations in wing design that can change wing camber midflight. By seeking a way to increase the coefficient of lift vs. the coefficient of drag ratio along with a higher lift force and lower drag force, higher efficiency would be achieved as planes can fly in the optimal state for given conditions based on various factors.

Methods/Materials
Due to the limited facilities available as a high schooler doing this project (no access to a wind tunnel or aerospace-grade materials), the design of four different airfoils was instead done on Autodesk Inventor Professional. All tests were subsequently run on Autodesk Computational Fluid Dynamics and VisualFoil 5.0, in order to determine the coefficients of lift and drag. While maintaining parameters such as air density, velocity, and wing surface area constant, the angle of attack was varied at four different positions among all airfoil designs. The force of lift and drag were calculated at each of these angles as well, and all data was subsequently compared to that of a Boeing 787's statistics.

Results
After collecting all data and analyzing the values of the four airfoils in comparison to that of a Boeing 787, the final results showed that utilizing this new airfoil design provided the same lift capacity at 5.6% less velocity and with a drag reduction of around 72%. As a result, this would require approximately 70% less engine power, leading to a substantial decrease in the amount of fuel and energy required to power the plane through its flight.

Conclusions/Discussion
I found that highly cambered airfoils were more efficient at lower angles of attack, and less cambered airfoils were better at higher angles of attack. The continuous-bodied airfoil that bends in shape is able to produce the same amount of lift coupled with a reduction in drag, showing its significant advantages over traditional aircraft with drag-inducing flap mechanisms. With less fuel and less power required to maintain the same flight conditions, it is in the best interest of the industry (lower operating costs), consumer (cheaper ticket prices), and environment (reduced emissions).

Summary Statement
I designed and tested an airfoil design that changes shape, and measured the effects that it has on lift and drag compared to traditional aircraft in the industry today.

Help Received
I taught myself how to use CAD software and run CFD simulations through various tutorials and forums on the internet. I spoke briefly with my flight instructor about my ideas and the concept I was trying to develop and test.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Michael A. Danielian

Project Number
S0307

Project Title
The Effect of Friction Drag on the Speed of a Roller Hockey Puck

Abstract

Objectives/Goals
The goal of this project is to find the material that best moves hockey pucks like they were on a roller hockey rink. This will be done by comparing the speed of the puck moving over different surfaces.

Methods/Materials
The way this was done was by building a machine, that with two DC motors, shoots a roller hockey puck in a straight line. On the floor are two strips of aluminum foil hooked to a Makey Makey that, when passed over, sent a signal to the laptop to start a code that measured the amount of time the puck took to go from the first to the second strip. With the code, an algorithm is used to display how fast the puck was going in kilometers per hour. The speed would then be recorded in a table, and compared to the other materials to compare the friction of the materials. As a preliminary test, the machine was shot over the surface that is actually used for roller hockey. This experiment was done twenty times for five different types of materials; concrete, wood, marble, asphalt, and fabric.

Results
The results showed that concrete was the fastest surface for the pucks to move over, with a mean speed of 5.4 kph. Then it was marble, with a mean of 4.1, then asphalt with a mean of 3.6 kph. The fourth was wood with a mean of 2.1 kph, then fabric, which had no successful trials. These values were compared to the speed of the preliminary test, which was the puck traveling over the roller hockey surface.

Conclusions/Discussion
From this project, it can be concluded that concrete was the best material. This project should help hockey players know that the best material to practice on that feels the most like the surface used in roller hockey is concrete since it has the least amount of friction of all of these different surfaces

Summary Statement
By using a self designed sensory and propulsion system, I tested and compared the speeds of roller hockey pucks over different materials.

Help Received
I constructed the measuring system and coded the program myself. My parents helped me buy the materials needed to complete this project. My teacher, Michael Lim helped me with any question I had for him.

Name(s)
Salvatore Deguara; Aiden Largay; Isaac Menge

Project Number
S0308

Project Title
Optimizing Surfboard Fin Design by Maximizing the Ratio of Lateral Resistance to Drag

Abstract

Objectives/Goals
The objective of our project was to measure the different forces exerted by surfboard fins. Our investigative question is "what fin is optimal for surfing local waves." Our hypothesis was that the fin with small width and large height would yield the most optimum results (low drag, and high lateral resistance).

Methods/Materials
We created the fins using Blender, a 3D modeling program and proceeded to 3D print them out and label them according to height and length. They were printed by a friend, Scott, at Tesla. In order to test lateral resistance, we built a contraption that would mount the board perpendicularly to the edge of the pool with the finbox area within the pool's jet stream. We used a standard, 5'10" surfboard with Future's fin boxes in them, which our custom fins fit into. We tied a rope to the tail area of the board, and attached it to a spring scale in order to measure the amount of drag. We repeated these tests for both lateral resistance and drag each five times per fin.

Results
After we finished the testing with the different fins, we found that in general the greater the surface area of the fin, the greater lateral resistance and drag it provided. More specifically we discovered that the length of the fin sideways is more correlated with lateral resistance than it is with drag, and the depth that the fin extends into the water is more correlated with drag then lateral resistance.

Conclusions/Discussion
We found that the fin with the optimal qualities had a small height and large length, which perfectly matched the description of fin 1-3. For the most part, these results tend to make sense because with a taller fin, the head-on drag should be increased, and with a longer fin, the lateral resistance should be increased. We determined this by looking the correlation values in the graphs of lateral resistance vs. length and drag vs. height. The correlation between lateral resistance and length was strong, and so was the correlation between drag and height. It was interesting to see that this style of fin is widely used among the surf community, and a common shape for surfing.

Summary Statement
We measured the drag and resistance forces provided by our different fins to determine the optimum one for surfing.

Help Received
We received help from Bryan Largay as he gave us ideas on how to set up our experiment and from

Name(s)
Aadi Duggal; Rishab Lenka; Adrian Liu

Project Number
S0309

Project Title
Investigating Fluid Patterns to Determine the Efficacy of an Airfoil

Abstract

Objectives/Goals
The focus of this research is on the optimization of wind power and airflow, and the experimental derivation of drag and lift on energy savings.

Methods/Materials
3D printed airfoils were created using the NACA 0012 airfoil and modifying the control group to biomimetically emulate natural designs such as Humpback Whale Tubercles as well. The force of drag was experimentally determined by measuring the amount the airfoil was pushed via a spring scale. The force of lift was experimentally determined by measuring the change in weight before and after the airflow over the airfoils.

Results
The results had shown a consistently lower drag force and consistently higher lift force in the experimental airfoil, with a delayed stall and flow separation as per the CFD (Computer Fluid Dynamics) simulations.

Conclusions/Discussion
Real world implications include reductions in the fuel economy of airplanes, windmills, next-generation cars, boats and other objects that move through fluids such as air or water.

Summary Statement
The aerodynamic efficacy of different airfoils, inspired from real world species, was determined by measuring the different aerodynamic forces on the airfoils, while a CFD simulation was used to verify our results and explain the mechanism.

Help Received
David Uken helped us in 3D printing our airfoil

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

William Dykes; Ayden Sabharwal

Project Number

S0310

Project Title

Which Major Brand of Shin Guard Provides the Most Protection to the Shin?

Abstract

Objectives/Goals

Determine which major brand of shin guard provides the most protection to the shin by using multiple impact methods and further prevent shin injuries using the data we gather.

Methods/Materials

Tested five different brands of shin guards by using multiple impact tests. Used cardboard and spaghetti to create a makeshift shin. Dropped a free-weight from a constant height in trials and created an impact. Shin guards were mounted on a makeshift leg (cricket bat).

Results

The tests my partner and I performed showed us that while being compared to the four other shin guards, the Puma shin guard provided the most protection. We found the Franklin and Martial Arts shin guard to be close competitors after the puma. Lastly, we found that the Nike and Adidas provided the least amount of protection.

Conclusions/Discussion

The performance of the Puma shin guard in our impact test was significantly better than the performance of Nike and Adidas. This experiment provides the idea that bigger brands don't necessarily provide the better product. The importance of this experiment is that it helps an athlete decide what brand of shin guard to choose which can help protect them from possible shin injuries.

Summary Statement

My partner and I devised an impact test to compare the strengths of shin guards.

Help Received

My partner and I designed the impact test ourself after trying multiple methods and reading an article published by SATRA Technology.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Laura Gong

Project Number
S0311

Project Title
Optimal Multi-Renewable Energy Generator: Year 2

Abstract

Objectives/Goals
The combustion of fossil fuels is the leading contributor to global warming. Reducing emissions of toxic elements by switching to renewable resources by harnessing energy from renewable sources is a necessary long-term solution. The first year goal was to analyze which areas along the coast of California and which specific weeks have the tallest ocean waves, producing more energy from a renewable source of ocean waves. This second-year goal is to create a physical energy generator that will harness energy from three renewable sources: ocean waves, winds, and the sun.

Methods/Materials
Three methods are harnessing energy from the three renewable sources. A floating structure with the cylinder inside generates energy from the vertical motion of ocean waves. The rise and fall of wave height will trigger an electromagnetic induced current and generate electricity. A vertical axis wind turbine will be used to generate energy from the wind since it generates energy from all directions of the wind. Solar panels will be used to generate energy from radiant heat and light from the sun. Regression analysis with collected data will be used to find the correlation of possible factors including wind speed, ocean wave frequency, and temperature to the amount of electricity generated by wind power, ocean wave power, and solar power, respectively.

Results
The overall station includes a floating structure with a tube perpendicular to it on the bottom. The wind turbine and solar panels will be located on top of the structure while the wave energy generator is located inside the cylindrical body. Wind speed and wave frequency have high linear correlations to amount of electricity generated.

Conclusions/Discussion
This new energy station was successful to generate energy from three renewable energy sources and is a good starting point for a more permanent energy source solution.

Summary Statement
I engineered a station that generates energy from three renewable energy sources- the sun, ocean waves, and winds.

Help Received
I designed and engineered the generator myself after taking multiple engineering courses in the past years. Mrs. Julie Munoz, my science research teacher, reviewed my research plan, abstract, and research paper.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Magnus B. Herrlin, IV

Project Number

S0312

Project Title

A Novel Method to Measure Surface Roughness by Using the Aerodynamic Magnus Effect

Abstract

Objectives/Goals

Based on the results from my 2017 California State Science Fair project, I hypothesized that the aerodynamic Magnus Effect could be used to measure surface roughness, which is important in many engineering applications. This year, I set out to find if this is possible. My earlier project suggested that a rough surface increases the Magnus Effect.

Methods/Materials

I tested my hypothesis by constructing a model of a Flettner rotor ship, which is a type of sailing ship that has vertical spinning rotors instead of sails. Rotor ships use the Magnus Effect for propulsion. I fabricated several exchangeable rotors with different grit roughnesses and measured the speed of the boat with each rotor under identical conditions. The rotors had all the same dimensions and they were ballasted to weigh the same.

Results

After refining the test setup and procedure, I performed a total of 80 tests and applied a power curve fit to the data with excellent result. Having the relationship between rotor surface roughness and boat speed in mathematical terms (power function), I could successfully determine the roughness of an unknown rotor by measuring the speed of the boat and using the inverse of the power function.

Conclusions/Discussion

The results from my experiment suggest that my hypothesis was correct; namely, that it is possible to measure surface roughness by using the Magnus Effect. Since none of my online searches uncovered such a use, I concluded that this project proposed something truly new and original.

Summary Statement

In my project, I attempted to measure surface roughness by using the Magnus Effect.

Help Received

My science teacher helped me by reviewing my preliminary report and giving me some advice.

Name(s)
Ken T. Hinh

Project Number
S0313

Project Title
Optimizing Architecture of Bioprinted Cardiac Tissue

Abstract

Objectives/Goals
The goal is to design and construct a geometry of 3D printed constructs that would address the 3D bioprinting issues of contractility, feasibility and functionality of cardiac tissues to, ultimately, serve as an alternative treatment for patients with cardiovascular diseases.

Methods/Materials
In this study, I will optimize the architecture of 3D-printed constructs to ensure that the parameters are sufficient to support 3D bioprinted cardiac tissues; consequently, I want to be able to predict the survivability and function based on the geometry of the 3D-printed construct. I designed each construct with computer-aided design software (OnShape) under 3D printing constraints. I calculated permeability of each construct with different geometries by measuring time with stopwatch and pressure with gauge. I used silicone oil to perfuse through each construct, deriving permeability from viscosity of the fluid, pressure differences, flow velocity, and thickness of the porous medium (construct). Practically, the experiment with silicone oil is a method to try to measure the permeability of the 3D printed construct based on Darcy's Law, an equation that describes flow of a fluid as it passes through a porous object.

Results
The permeability of the 3D constructs with numerous holes was compared after passing through silicone oil versus after passing through a 2D construct with fewer holes. The 2D waffle construct had the lowest permeability average of 0.899 H*m^-1 while 3D cross-section construct had the highest permeability of 2.967 H*m^-1. The permeability of the 3D construct was shown to be the highest, which indicates that the 3D construct is the most effective.

Conclusions/Discussion
The performance of the 3D cross-section construct for exhibiting the highest permeability under 3D printing constraints was higher than that of the 2D construct. This means the 3D cross-section construct can be used as the primary model for a 3D bioprinted cardiac tissue. This reveals that the 3D construct had the allowed for the highest permeability because, according to Darcy's law, mechanical forces are constantly changing through a 3D matrix architecture, which allows for an extended period of flow rate.

Summary Statement
I designed and constructed the most optimal geometry for bioprinting cardiac tissues by experimentally calculating their permeability using the perfusion of silicone oil through 3D-printed plastic construct

Help Received
I designed and performed the experiments myself. I got help in understanding how to operate and convert files for the 3D printer initially.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Spencer A. Krock

Project Number
S0314

Project Title
Proof of Concept Modeling of Venus Atmospheric Maneuverable Platform Utilizing Earth-Bound Modeling

Abstract

Objectives/Goals
The goal of the project was to compare how a physical model of the Venus Atmospheric Maneuverable Platform responds in Earth's atmosphere when filled with air or helium. The hypothesis of the study is that while the aircraft's inflatable wing structure is filled with air, the plane will not exhibit characteristics of flight, but if the wings are filled with helium, then the aircraft will glide.

Methods/Materials
The model was made by using Mylar balloon material to make the wings the desired shapes. The fuselage of a foam glider was used for the fuselage of the model, and a remote control helicopter was deconstructed to serve as the propulsion system for the model.

Results
During experimentation, it became immediately evident that the helium was positively impacting the way the plane flew above and beyond the air-filled model. The data supports the hypothesis, demonstrating that in tests of average flight time and flight speed, the helium-filled aircraft showed greater characteristics of flight and potential for long term sustained flight.

Conclusions/Discussion
It was determined that the scale model is not yet ready to be compared to the commercial design for VAMP. However, the data supports the hypothesis, demonstrating that in tests of average flight time and flight speed, the helium-filled aircraft showed greater characteristics of flight and potential for long term sustained flight. With modifications to the model, the model could be used to analyze he VAMP to improve the design.

Summary Statement
By constructing the first hybrid scale model of the Venus Atmospheric Manueverable Platform, I have identified variables that need to be explored further for improvment in the design.

Help Received
I constucted the model myself, but consulted with Mr. Daniel Sokol from Northrop Grumman for advice on the project. My father, Dr. Kevin Krock, also assisted in helping select the ideal materials for the model construction

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Kevin Kuehn

Project Number
S0315

Project Title
Two Phase Immersion Cooling of Desktop Computer

Abstract

Objectives/Goals
The goal of this project is to build a self-contained two-phase immersion cooling unit that can effectively dissipate the heat from a full size ATX form factor desktop computer being used to mine cryptocurrency. The criteria and constraints for this project is that it must be able to run cryptocurrency mining software for 30 minutes. The temperature on both the GPU and the CPU must not exceed their manufacturer specified maximum limits (98C and 80C respectively).

Methods/Materials
Construction and testing of this two-phase immersion cooling system followed this structure:
1. Construct enclosure, lid, attach input/output fittings
2. Assemble computer components onto the sliding tray
3. Assemble radiator and pump system and fill with coolant
4. Fill system with Novec fluid
5. Power on and verify function
6. Run benchmarking software for 30 minutes
7. Record temperatures of the CPU, GPU, Novec fluid, and ambient air

Results
The results of the thirty-minute stress test indicated that the two-phase immersion cooling unit was successful. The CPU reached a maximum temperature of 74 degrees celsius and the GPU reached a maximum temperature of 65 degrees celsius at an ambient temperature of 27 degrees celsius.

Conclusions/Discussion
In conclusion, the two-phase immersion cooling unit was successful in keeping the full-size computer components cooled below their maximum temperature during a thirty-minute stress test utilizing only one gallon of Novec 649.

Summary Statement
I created a two-phase immersion cooling system that is capable of dissipating the heat from a desktop computer running cryptocurrency mining stress tests for at least thirty minutes.

Help Received
I designed, built, and tested the immersion cooling unit myself. I received a one gallon sample of Novec 649 from 3M.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Austin Lam

Project Number
S0316

Project Title
Effect of Non-Tip Wing Structure on Performance of Aircrafts

Abstract

Objectives/Goals
The objective of this study is to determine the efficiency of a closed-wing design in lieu of the modern wingtip design to eliminating drag caused by wingtip vortices.

Methods/Materials
Initial prototypes used cardboard, tape, and wood skewers for proof of concept. Data collection involved using force sensors, for which an apparatus was built in order to suspend the airfoil in a 23cm deep wind tunnel at varying wind speeds.

Results
Five trials of 20 seconds for each of the two wing designs produce a graph that indicates the average lift to drag values of each wing. The traditional wing has a higher lift to drag ratio than the closed wing does, but is only observed at lower wind speeds.

Conclusions/Discussion
The data supports my hypothesis, but improvements are to be made to make further claims. Continued experimentation should include a larger wind tunnel which allows for smoke testing to see traveling wake as well as for larger airfoils which minimize surface inconsistencies by scale. As of today, limitations of using the closed wing include it not being all of the following: cheap, light, structurally sound.

Summary Statement
I created different airfoil designs to be tested for efficiency in minimizing wing-tip drag

Help Received
My research class teacher and an undergraduate mentor helped me to create an airfoil, to find the best way to collect valid data, and to convey my scientific findings in a public manner.

Name(s)
Rei J. Landsberger

Project Number
S0317

Project Title
Design and Mechanical Analysis of a Promising Hip Prosthesis Using Quaternions

Abstract

Objectives/Goals
Conventional ball-and-socket hip prostheses suffer from challenges that include painful dislocation requiring surgical revision, material wear, and bio-contamination from wear particles leading to bone loss and prosthesis failure. A new hip prosthesis design to address these problems has been developed, modeled mathematically, and tested in a laboratory framework.
The first objective of the study is to analyze and validate the improved movement range of the new, patent-pending hip prosthesis design employing a gimbal or universal joint. A second objective is to determine load-carrying capacity and predict durability under day-to-day loading.

Methods/Materials
The investigation, modeling and analysis and validation of both joint motions and forces has been performed both using a hand-made physical model with an instrumented skeleton and test frame and through a computer using the Mathematica(R) Language with conventional Eulerian Angle transformations and Quaternion approaches.

Results
Adding not just one but two rotational bearings to a standard Universal joint is found to create an extra degree of rotational freedom enabling a greater range of motion. The extra rotation comes into play when the U-joint nears a position when the three rotational axes lose their linear independence - a condition termed gimbal lock in the mathematics and aerospace vocabulary.

Conclusions/Discussion
The ability of the U-joint prosthesis to operate smoothly and safely with adequate range of motion, last indefinitely due to minimal friction U-joint designs, maintain isolation from the body to reduce possible infection of the joint, and not be dislocated shows potential improvement over existing prostheses and worthy of future study and clinical experimentation. The durable design may find applications to other joints of the body, including shoulder and knees.

Summary Statement
Building from my previous year's research that investigated a new hip prosthesis design using a Universal/gimbal joint, this year's study analyzed (Eulerian Angle transformations and Quaternion approaches) how this new hip prosthesis design

Help Received
I received verification of the unique prosthesis design from Dr. Rama Chandran, an orthopedic surgeon. My father helped supply tools and guidance in building the test frame for a part of the study.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Joshua Lee

Project Number
S0318

Project Title
Inexpensive, Fluid Convection Based Central Processing Unit Cooler

Abstract

Objectives/Goals
The following research was done on an attempt to design a low-cost CPU cooler capable of handling high heat loads normally produced by high-end CPUs utilized by gamers or overclockers. Although many high-end cooling solutions insist upon using a mechanical pump, natural movement of particles via heat-gradient induced convection shows promise in becoming a cooling solution suitable for dissipating high heat loads.

Methods/Materials
In this research, the cooler was required to effectively dissipate heat loads generated by three different maximum CPU configurations. The first and second configurations was two different CPUs, producing 2 different heat loads, 54 W and 95 W. Additionally, one of the CPUs overclocked from 4.3 GHz to 4.8 GHz to produce an overclock heat load of 180 W. The heat load(W), temperature(C) of CPU, and time was all measured using third-party open-source software. The prototype was constructed from 11 ft of copper tubing, stumps of vinyl tubing, a copper block(from a vendor), and later an Intel-certified aluminum heat spreader. A cooling fan was placed near the copper tube to aid with the heat dissipation. To test the efficacy of the prototype, the prototype had two different comparison standards. The first method was an Intel-licensed stock cooler complimentary with a new processor. The other cooling solution was a high-end pump-powered cooling system.

Results
After testing the two different heat loads, the prototype was 20C more efficient than the stock cooler. Unfortunately, the prototype failed to keep the CPU at safe temperatures at the designated overclock frequency. Furthermore, the pump-powered cooler was 28C cooler than the prototype at 95 W testing, with the prototype constant at 88C. Also, calculations made to determine thermal resistance found 1.055, 0.74074, and 0.444C/W, for the stock, prototype and pump cooling, respectively. Testing revealed evidence of convection, as the top pipe was warmer than the lower pipe.

Conclusions/Discussion
Ultimately, the prototype could not compete with the pump-powered cooler, but with a cost difference of $30 to $200, the prototype was a better value cooler. Overall, this research session concluded with the preliminary development of a convection-based cooler that could handle up to 100 W of heat load. With sufficient redesign and retest, this project may be a gateway into a world with more efficient, budget-oriented cooling systems.

Summary Statement
This project designs and tests an inexpensive CPU cooler prototype that relies on liquid convection rather than mechanical movement of fluids.

Help Received
None. I designed the prototype and built the computer systems, and pump cooler myself. I also tested and analyzed data.

Name(s)
Ken C. Lew

Project Number
S0319

Project Title
Graphene Oxide Advancement in Technology: Nanoparticle Application in Carbon Fiber Aircraft Design

Abstract

Objectives/Goals
This project is to identify the ideal concentration of Graphene Oxide on carbon fiber and how variation of the graphene oxide concentration affects the tensile strength. I believe as the concentration of the graphene increases, the tensile strength will also increase. If proven successful,an implementation of the enhanced carbon fiber material will be applied to the construction of a prototype radio controlled plane.

Methods/Materials
I used carbon fiber, epoxy, and graphene oxide to create the samples. The independent variable in this case was the % concentration of graphene in the sample controlled by ratio of added graphene oxide to epoxy. Tested the tensile strength of the graphene oxide carbon fiber samples using an UTM(Universal Testing Machine) at Qualcomm Quality Lab and used their camera to take cross sectional pictures. Downloaded the free Autodesk Fusion 360 CAD program online and used for designing some of the RC plane parts and performing simulated stress tests. To construct plane, I used a foam body wrapped with enhanced and un-enhanced carbon fiber, various electrical parts was then inserted and connected by wires such as the motor, battery, and flap control. 2% enhanced carbon fiber was placed strategically in places where high stress would occur during flight; wings and midsection where wings were connected to body. Other parts of the plane were treated with 0% graphene carbon fiber. Flight test occurred after the final construction.

Results
The 2 samples that had the highest load capability contained 2% applied graphene oxide. The 20 additional constructed samples with 2% Graphene were tested and held similar tinsel strength values varying between 1200-1550 (lbf). Cross sectional analysis at the microscopic level showed nano-particle layers forming on the exterior of the carbon fibers for the 2% Graphene sample.

Conclusions/Discussion
The addition of Graphene nano-particles had shown greater load capabilities that grew as a greater concentration of Graphene was applied. The data shows that Graphene had increased the physical properties of the carbon fiber however as more graphene was applied the less elastic it became. The new composite material with 2% Graphene Oxide was then applied to load bearing parts of the RC plane (outer skin and support sections on the wings) to create a lighter and stronger aircraft.

Summary Statement
Graphene Oxide applied to carbon fiber shows an increase in the tensile strength, when used in a plane design it allows for a lighter and stronger aircraft.

Help Received
Qualcomm Quaility lab performed the UTM measurements and took cross sectional pictures.

Name(s)
Benjamin C. Liu

Project Number
S0320

Project Title
Development of a Fully-Integrated Microfluidic System for Rapid Diagnosis of Infectious Diseases and Cancer

Abstract

Objectives/Goals
RNA analysis requires multiple lab processes that are expensive, tedious, susceptible to cross-contamination, and reliant on skilled operating. The goal of this project is to create a fully-integrated microfluidic system incorporating a 3D cartridge, battery-powered portable instrument, and smartphone-based fluorescent scanner that can perform nucleic acid sample preparation, separation and purification, amplification, and detection.

Methods/Materials
Individual technologies that were designed, tested, and optimized included 1) an electrochemical micropump, 2) wax microvalves, 3) acoustic micromixers, 4) reagent-storing blisters; 5) 3D layer stacking; 6) a portable battery-powered instrument for cartridge operations. The integrated system was tested with 4 cancer cell lines derived from cervical and breast cancer before being tested with clinical urine samples infected with Chlamydia Trachomatis and Mycoplasma Genitalium. Results were analyzed at each stage of the diagnostic process to optimize RNA extraction efficiency, RNA purity, and signal amplification. Comsol Multiphysics was used to study reactions in acoustic micromixing.

Results
The acoustic micromixing method significantly reduced sample preparation times from several hours to seconds. The electrochemical pump, wax microvalves, 3D design, and reagent-storing blisters were optimized for regulation and successfully facilitated fluid flow operations for maximization of RNA separation and purification. CFD models successfully validated acoustic interactions seen in cellular interactions to optimize sample preparation and RNA capture. The cell-phone-based fluorescent scanner successfully detected fluorescent signals in amplified samples. The integrated system performed sample-to-answer analysis on 6 different infectious diseases and types of cancer with diagnostic results comparable to modern-day-technologies, with an RNA extraction rate of 65% and production of high-purity RNA.

Conclusions/Discussion
The developed system produced consistent diagnostic results among 6 different types of diseases that were comparable to those of modern-day-technologies. It displays the potential to diagnose hundreds of other infectious diseases and cancer-causing mutations for use in everyday households and at the point-of-care. Many of the engineering components are transferable to a variety of microfluidic platforms for other biotech and analytical applications.

Summary Statement
My project is about the development of a fully-integrated microfluidic system for sample-to-answer diagnostics consistently demonstrated successfully among 6 different infectious diseases and types of cancer.

Help Received
Lab equipment was provided by Dr. Eva Mcghee. Results and future directions were discussed with Dr. Eva Mcghee and Mohammad Agahmoo.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Callie M. McCaffery

Project Number
S0321

Project Title
Birds, Planes, and Winglets

Abstract

Objectives/Goals
Does adding winglets to the ends of wind turbine blades affect the wind turbine's performance compared to a wind turbine with blades that have no winglets?

Methods/Materials
I designed and built my own wind turbine and wind tunnel that would allow for testing of different blade configurations. Data was gathered by counting rotations per minute.

Results
I found that winglets do affect wind turbine performance. I ran three different tests, making changes to each wind turbine blade design that focused on eliminating extra variables, such as center of gravity differences. After completing the testing analysis, I ran a fourth test that demonstrated some clear benefits to winglets.

Conclusions/Discussion
I found results that supported both advantages and disadvantages to winglets on wind turbine blades. Blade design appears to be a critical factor, and based on my results, I believe that continued testing in this area would be appropriate. Just as winglets on airplane wings have increased efficiency, saving millions of dollars, I believe that improved wind turbine blade design could increase wind turbine efficiency as well.

Summary Statement
Adding winglets to the blades of a wind turbine affects the performance of the wind turbine.

Help Received
My engineering teacher reviewed my theories and sketches. My science teacher and mentor assisted with review of materials and project concept. My parents assisted with some material construction, and data recording.

Name(s)
Yiyi Ouyang

Project Number
S0322

Project Title
Flight Analysis of a Winglet's Effect on Aircraft Performance Inside a Subsonic Wind Tunnel

Abstract

Objectives/Goals
The goal was to measure lift (via weight) and drag (via Hooke's Law) on wings with varying cant angles in subsonic conditions with a 2-degree angle of attack.

Methods/Materials
3-D Printer, Fan, Wooden planks, Powertools, Spring, and scale. I used plywood and the fan to construct a wind tunnel. The 3-D printer fabricated the wing which was tested with a spring and scale.

Results
The wing with the cant angle of 110 performed the best based on its lift to drag ratio. It had the highest lift to drag ratio with a cant angle of 100 being the next highest. There may have been inconsistencies with the wall effect and thus a margin of error of around 15 degrees can arise.

Conclusions/Discussion
It seemed that at 110 degrees, the spillover effect of high-pressure wind to low-pressure wind was the least. This means that a cant angle of 110 degrees may be best at conserving oil, increasing mileage, and decreasing wingtip vortices.

Summary Statement
I used Hooke's law to measure drag and a scale to measure lift inside a self-constructed wind tunnel.

Help Received
My dad cut the wood. I used the drill and constructed the wind tunnel by myself.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Junho Park

Project Number
S0323

Project Title
Exploration of Drone Models and Movements

Abstract

Objectives/Goals
Does the expensive drones have better control and stability compared to the cheaper ones. This experiment tests four different drones at different price points ranging from $15 to $200.

Methods/Materials
The material list includes: one parrot rolling spider, Codrone pro, LBLA mini drone, Hasakee H6 foldable drone, timer, and meter stick. Comparing stability and functions of 4 drones by controlling them in a same amount of time.

Results
The $25 Hasakee drone was able to perform the best out all four drones. The movement on the Hasakee drone performed 40% faster. The drone's best performance was in the execution of the yaw rotation, which was 2.5 times faster than the slowest drone. The worst drone was the LBLA drone because it barely passed the basic movement test. It failed the combination movement tests. The ranking of performance from best to worst was Hasakee, Parrot, Codrone, and LBLA mini. On a side note, the Parrot had the best execution of combination movements, making it a better precision drone.

Conclusions/Discussion
My experiment did not prove my hypothesis that drones that are more expensive will have better control than the cheaper models. While the $50 Parrot drone had the best control, the Codrone could lacked the ability to perform as precisely. The $15 LBLA drone had the poorest control.

Summary Statement
The controls of the drone do not depend on the price.

Help Received
I received help from my parents who helped me to purchase my research materials and support me. I also want to say thank you to my mentor Tim Kim.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Mia A. Placencia

Project Number
S0324

Project Title
An Assessment of the Effectiveness of Human Hair Hygrometers

Abstract

Objectives/Goals
The objective of this study is to test the efficiency of hygrometers made out of human hair in determining humidity levels.

Methods/Materials
A digital hygrometer (used for comparisons and collaboration), three strands of three different hair types (curly, straight, bleached), wood, plastic, nails, shower and hair dryer. Hygrometers were made out of human hair to predict humidity levels and they were compared to a digital hygrometer to test effectiveness.

Results
After taking humidity levels of both the hair hygrometers and the digital hygrometer over the course of seven days, the hygrometers on average had a confidence level of 99.99%. They reacted effectively to humidity levels in the air.

Conclusions/Discussion
The hair hygrometers had confidence levels all over 99% which concluded that they were effective enough to predict humidity levels. A personalized hair hygrometer proved to be a less-expensive way to predict the weather and can also help predict bad hair days.

Summary Statement
I showed that a hygrometer made of human hair can be as effective in determining humidity levels as a digital hygrometer

Help Received
I built and tested the hygrometers myself. I recieved help gathering materials and understanding the statistical analysis from my mentors in the Summer Science Institute.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Remy A. Reeb

Project Number
S0325

Project Title
Reducing the Incidence of Scald Burns in Children Age Five and Under

Abstract

Objectives/Goals

Problem: The leading cause of scald burns among children age five and under is due to a child pulling a pot or pan with hot contents in it off of a stovetop and the pan contents landing on the child.

Hypothesis: The incidence of scald burns among children age five and under can be reduced by creating a scald prevention device that prevents a child from being able to pull a pan off of a stovetop in a home kitchen, thus preventing hot contents in the pan from landing on the child.

Methods/Materials

To determine the pulling force that children exert that the scald prevention device would need to resist, the strength of 27 children age three to five was tested. The children pulled four times on a weight scale placed at the height where a pan handle would be on a standard stovetop. 13 configurations of scald prevention devices were created and tested for their ability to withstand a pulling force. The devices were tested at seven positions around a pan. The devices had four main components: 1) a cooktop anchor (magnets, suction cups, permanent clips), 2) a clip, 3) a tether, and 4) a clamp (connected to the pan). The pan was placed on a cooktop, a hook was attached to the end of the pan handle, and a bucket was attached to the hook. Weights were progressively placed into the bucket until the device failed (pan tilt angle of 25 degrees or pan came off cooktop). 562 trials were run, including base cases with no attached scald prevention devices.

Results

Seven of the scald prevention devices withstood the force of weights exceeding the maximum pulling strength of all the children tested (13 kg) when the scald prevention device was in position 4 (directly opposite the pan handle) or position 3/5 for two-anchor devices. 12 out of the 13 devices tested withstood the average pulling strength of each age group (3-year olds 5 kg, 4-year olds 6kg 5-year olds 9kg). The anchor and clamp positions significantly impact the results.

Conclusions/Discussion

Use of a properly positioned scald prevention device that anchors a pan to a cooktop and has sufficient weight resistance will reduce the incidence of scalding burns in children age five and under by preventing a child from being able to pull a pan off a cooktop.

Summary Statement

I created a device that will effectively reduce the incidence of scald burns among children age five and under.

Help Received

Numerous people provided guidance and insights regarding my project including: Jeremy Humphrey donated the stove I used in my testing, Matt Lopatka provided guidance regarding fail testing, my science teacher provided project guidance, and my father helped along the way.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Tyler E. Robertson

Project Number
S0326

Project Title
Project POWER: A Swift Water Warning System

Abstract

Objectives/Goals
Every spring, people drown in local rivers because they underestimate the power and danger of the river flow from melting mountain snow. Project POWER (Predicting Onsite Water Entry Risk) is a portable swift water warning system that is designed to visually alert swimmers of dangerous water conditions.

Methods/Materials
The buoy is constructed of PVC pipes and rust resistant metals. A digital flow meter is connected to an Arduino microcontroller that controls the color of RGB LED strip lights located above the water line. When water velocity reaches a set threshold, the flashing LED lights change from green to red. The Arduino and LED lights are powered through a 12Ah charging battery, which is connected to a 9W solar panel. After calibrating the flow meter for accurate measurement and performing buoyancy tests in a pool, the buoy was tested in the Tule River with an across-the-river anchor line. Using a pulley system, the buoy was positioned in the area of highest water velocity at the center of the river.

Results
The buoy anchoring system worked well with the across-the-river control line. The control box remained waterproof and the LED lights changed color when the threshold water velocity was reached. The buoy demonstrated the ability to stay afloat in the higher currents. Flow meter accuracy was reduced due to the vertical position of the buoy in the river which limited the amount of water passing through the flow meter. An external flow meter was then tested resulting in more consistent river flow measurements.

Conclusions/Discussion
Project POWER demonstrated the potential to save lives by alerting swimmers of unsafe river conditions. Future designs will include a temperature sensor, audio alerts, and smart phone applications.

Summary Statement
I designed and built a swift water warning buoy that visually alerts swimmers of unsafe water currents.

Help Received
A member of the Tulare County Sheriff's Swiftwater/Dive Rescue team assisted with buoy placement on the Tule River.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Isak R. Traustason

Project Number
S0327

Project Title
The Effect of a Wing's Winglet Length on Its Lift

Abstract

Objectives/Goals
My objective is to learn how the length of a winglet changes a wing's amount of lift. For this experiment, the hypothesis is that the wing with a winglet of 5 cm creates the most lift.

Methods/Materials
Materials
Box, Jump house pump, Hotwire cutter, EPP Foam, Balsa, Scale, Wooden Dowel
Materials
hot wire cutter was created, using red oak wood, galvanized steel wire of 24 gauge, a lithium polymer battery for power, springs, and finally alligator clips to wire everything together.
A wing was created, using insulation foam, and a template of an airfoil, which allowed the hot wire cutter to slice through the foam following the template giving a smooth, and accurate airfoil.
A wind tunnel was created, using a long box with 2 openings, and paper tubes, in order to smooth out the air for more accurate results, and a wooden dowel, which attached the wing to the scale.
Testing was done, by zeroing out the scale, aligning the bounce house pump at the entrance turning it on and recording the measurement given by the scale in grams.

Results
As can be seen by this data (Figure A and Figure B) it shows that changing the length of the winglet does dramatically affect the lift. In figure 1 the graph shows that the standalone wing without a winglet produces about 172.6 +/-3% grams of lift. However the wing that used a winglet of 5cm resulted in producing 184.3 +/-2.5% grams of lift. This shows about a 12 gram increase of lift from the standalone wing. But the winglets that were 7.5 cm to 10cm, showed a very large drop in lift, with the 7.5 cm winglet only producing about 115.6 +/-6% grams of lift and the 10 cm winglet producing a sligh more at 121.7 +/-6% grams of lift. However as, the winglet length exceeded 7.5 cm there was a very large deviation compared to the winglets under 5cm. The trend in this graph shows that a winglet about 5cm has the most lift, but as the winglet length starts increasing it loses a lot of lift.

Conclusions/Discussion
The data ultimately proves that a winglet that is 5 inches or half the size of the wingspan does produce the most lift. This shows that it is the most energy efficient, with lightweight. However, this can't be implemented on full-sized airliners since a winglet that is half the size of the wingspan would be unpractical and would not work. I accomplished the fact of finding the best point of lift, and energy efficiency in a small scale model wing.

Summary Statement
How does the length of a wiglet compared to the wing size affect the overall lift of the wing.

Help Received
Trausti, Dworzak

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Tristan H. Williams

Project Number
S0328

Project Title
Efficiency of Multi-Bladed Propellers

Abstract

Objectives/Goals
In my experiment, I attempted to figure out how many blades on a propeller were most efficient. I examined 4 different types of propellers: a two bladed propeller, a three bladed propeller, a four bladed propeller, and a six bladed propeller.

Methods/Materials
During my experiment, I examined 4 different types of propellers: a two bladed propeller, a three bladed propeller, a four bladed propeller, and a six bladed propeller. By using a thrust stand and program developed by RC Benchmark, I tested each propeller on the stand to find the thrust, voltage input, amperage input, total wattage input, and propeller rotation speed.

Results
At the end of my experiment, I concluded that the two bladed propeller was the most efficient of the four even though it generated lower amounts of thrust. The power that the propeller used was also substantially less compared to the other propellers which led to it being more efficient.

Conclusions/Discussion
The efficiency of of propeller blades contributes greatly to the flight time and range of aircraft. People who fly aircraft that do not use a turbine to generate thrust may be interested in some factors and information which may adjust the efficiency of the propeller blades that they may be using.

Summary Statement
I am attempting to find how many blades on a propeller is most efficient using a thrust stand and computer program.

Help Received
I set up and tested my experiment without any help . I got some help from my mom while editing.

Name(s)
Jeffrey J. Wisoff

Project Number
S0329

Project Title
What Does the Brain Feel? Assessing Skull to Brain Impact Dynamics to Inform Improved Bicycle Helmet Design

Abstract

Objectives/Goals
Over 15% of deaths in bicycle accidents occur while the riders are wearing helmets. Current bicycle helmet impact testing focuses on measuring the reduction in G forces by using calibrated drop towers to inflict shocks into simple metal head assemblies outfitted with accelerometers. This method of testing does not measure the stresses transferred to the brain because the brain is not physically modeled. The purpose of this work was to investigate the skull to brain impact dynamics using similar test conditions but replacing the simple metal head with an instrumented model brain inside a 3D-printed skull.

Methods/Materials
A modified weight lifting machine served as a drop tower and photo sensors were used to measure the impact velocity achieved. The head assembly consisted of an anatomically correct 3D-printed skull encasing a model brain cast from 0.5% agarose gel, mimicking the physical properties of the brain. Both the skull and brain were equipped with accelerometers designed to measure the x,y,z accelerations up to 200 G. Two different helmet designs were tested on three impact surfaces.

Results
Results showed that the G loads transmitted to the brain were 10-30% lower than those transmitted to the skull, but the direction of the acceleration between the skull and brain changed significantly on impact. These results indicate that the brain may suffer shear forces in addition to compression forces, indicating more damage to the brain tissue. Both helmet designs tested showed similar results.

Conclusions/Discussion
An experimental drop tower for testing bicycle helmets using an instrumented skull/brain model was successfully demonstrated giving insights not available in current helmet certification testing where only a simple metal model of the head is used. The drop tests confirmed the hypothesis that the acceleration in the brain is lower than that experienced by the skull and that softer impact surfaces like dirt generate less G acceleration than firmer surfaces like cement. Most significantly, test results show the acceleration direction of the brain relative to the skull can change abruptly on impact, indicating a torque on the brain that induces shear forces in addition to compression forces. Higher fidelity helmet testing that incorporates a realistic instrumented skull/brain assembly should be performed to inform new helmet designs to minimize induced torques.

Summary Statement
Using a realistic helmet/skull/brain assembly instrumented to measure the accelerations transferred to the brain, I showed the brain can suffer both shear and compression forces during a simulated bicycle accident.

Help Received
I designed, built, and performed the experiments myself. I presented an overview of my project to my science teacher, Mr. Brix, before starting the project.

Name(s)
Duke J. Wu

Project Number
S0330

Project Title
The Effect of Changing the Number of Propellers and Number of Blades on Each Propeller on a Drone's Lift Force and Speed

Abstract

Objectives/Goals
The goal for this experiment was to find the capabilities of different types of drones. The usage of multiple drones allows for the comparison to find which drone is best compatible with which situation.

Methods/Materials
The experiment was done with the construction of a cardboard contraption that would surround the drone. Underneath the drone was a 9.5 cm rubber band that was attached to the drone. The drone would be flown up, and the rubber band would b.e measured in order to compare against the results for the other drone.

The drone was next tested by seeing how fast it could complete a one meter distance. The drone was timed and reviewed through a camera to determine the speed.

The motors also had the propellers replaced with two, three, and four bladed propellers to provide a wider range of data.

In order to create the hexacopter and octocopter, I designed the added on section to the quadcopter as well as soldering on the extra motors needed for the drone.

Results
The drones had the consistent pattern that is expected when considering quadcopter, hexacopters, and octocopters. There was a slow increase in height, at about 0.1 cm between most of the averages that were taken. For the speed, the drone got faster with the decrease of motors, ranging from 0.90 seconds to 1.5 seconds.

Conclusions/Discussion
The hypothesis for the experiment wasn't supported by the data, as the octocopter with two blades on each propeller provided the most average results between the two sets of data, making it most optimal for usages within delivery systems. The octocopter is able to travel relatively quickly while producing much force, allowing it to carry heavier objects.

Summary Statement
This experiment allows for the understanding of the capabilities of different types of drones through tests involving the drone's speed and lift force.

Help Received
Mr. Michael Lim, Xuqiang Wu, and Tongyi Shen