73rd Annual Fair

# Connecticut Science & Engineering Fair

March 8 - 20, 2021

# Student Abstracts

## High School Physical Sciences

## Fair Categories

| | Life Sciences | Physical Sciences |
|---|---|---|
| 7th & 8th Grade Team | LT (1001 – 1999) | PT (4001 – 4999) |
| 7th Grade | L7 (2001 – 2499) | P7 (5001 – 5499) |
| 8th Grade | L8 (2501 – 2999) | P8 (5501 – 5999) |
| High School | LS (3001 – 3499) | PS (6001 – 6499) |
| High School Team | LST (3501 – 3999) | PST (6501 – 6999) |

## Special Categories

| | |
|---|---|
| AT = Applied Technology | EE = Engineering: Electrical & Mechanical |
| AS = Animal Science | ET = Energy & Transportation |
| BE = Behavioral & Social Sciences | EV = Environmental Analysis |
| BI = Biochemistry | EM = Environmental Management |
| CB = Cellular & Molecular Biology | MA = Mathematical Sciences |
| CH = Chemistry | ME = Medicine & Health Sciences |
| CS = Computer Science | MI = Microbiology |
| EA = Earth Science | PH = Physics & Astronomy |
| EN = Engineering: Materials & Bioengineering | PS = Plant Science |

## Special Category Composites

| | |
|---|---|
| Biotechnology | AS, BI, CB, EN, ME, MI, PS |
| Environmental | EV, EM |
| Engineering | EN, EE |
| Sustainability | EA, EN, EE, ET, EV, EM |

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 249 | PS | 6001 |

**Title:** Finding optimal size for pooled testing of SARS-CoV-2

**Student Name(s):** J. Li

**Abstract:**

The spread of COVID-19, kindled by a lack of mass testing in early stages, has affected hundreds of millions of lives. Even with recent vaccination developments, such testing is still critical. Thus, a timely, cost-efficient method for extensive testing is imperative for fighting the pandemic. One solution is pooling multiple samples into a single PCR test. This study aims to determine the optimal size of these pools based on prevalence rate. R was used to simulate pooling in a population with a prevalence rate of 0.05. This revealed a binomial distribution, where each positive case in a pool represents a "success." The following formula (1) was derived: F=((1-P)^n)-(1/n), where F is the reduction factor, n is the pool size, and P is the prevalence. Plotting F vs n showed a single relative maximum in the first quadrant, thus the equation (n^2)((1-P)^n)*(ln(1-P))+1=0 for optimal pool size was found by setting the derivative of equation (1) equal to 0. As prevalence increases, pooling efficiency decreases. For instance, at P=0.005, the optimal pool size of 15 can save 86% of tests that would be needed, but at P=0.2, the optimal pool size of 5 can only save 13%, and at P=0.3, reduction is negligible. Overall, the formulas allow for accurate estimation of reduction factor and optimal pool size, not only useful for COVID-19 but also for future situations that require mass testing.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** MA ME BE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 247 | PS | 6002 |

**Title:** Comparing wood/plastic composite & hemp/polylactic acid composite to determine the best moisture resistant material

**Student Name(s):** S. McLemore

**Abstract:**

The Earth Day movement, started in 1972, ushered in increased concern for the environment resulting in recycling programs for a variety of products including plastics. At the same time, petroleum-based plastics were recognized as a finite resource stimulating development of bio-based polymers each with unique properties based on polymer type and other materials used. For example, cellulose-based materials are often added to plastic composites to provide stiffness and reduce weight. Cellulose is inherently hygroscopic and understanding its effect on composite moisture behaviour is important for ensuring proper utilization and long service life. This experiment compared the effects of water immersion of a wood/plastic composite (Trex) or a hemp/polylactic acid (PLA) composite with solid cedar, pine, and teak by measuring moisture uptake and dimensional stability. Six samples of each material (approximately 19 mm thick by 6 mm wide by 64 mm long) were weighed (nearest 0.01 g) and their dimensions measured (nearest 0.5 mm). Three samples were immersed in tap water at room temperature (temperature range of 19 °C) and the remainder were immersed at 3 °C. The samples were reweighed and measured after 30 days. Trex absorbed more water than the hemp/PLA filament but both absorbed far less water than the wood samples. Trex contains about 60% wood while 3D-Fuel's hemp/PLA filament contains 7%-8% hemp. It is also important to note most swelling occurs tangentially. As a result, each sample's thickness had the most percentage change in dimensions.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN EV

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 250 | PS | 6003 |

**Title:** Uncovering Abnormalities in Asteroids Using Asteroid Occultation

**Student Name(s):** K. May

**Abstract:**

It is important to define the shape of asteroids in space to understand the origins of our solar system. The purpose of this study is to determine the shape and size of asteroids using occultation analysis to discover abnormalities. It is hypothesized that asteroid occultations can reveal asteroid irregularities because accurately timing and combining the occultation duration from multiple locations can determine the shape and abnormalities of the asteroid. We conducted the occultations with a PlaneWave telescope, a WATEC camera, and a video time inserter, which used GPS satellites. To observe and analyze an occultation, the target star was located. Specialized computer programs were used to measure changes in brightness of the star during the occultation event. We observed five occultations and while three of them did not occult due to weather, we were able to precisely measure and create predicted images of two of the asteroids. The shape and size of the asteroids were used to attempt to discover any abnormalities. Through this study, we discovered a concavity abnormality in asteroid Lanzia, which suggests an indent from a stray projectile or the possible fusion of multiple asteroids. This study created an opportunity to observe objects in space to discover a feature previously unknown by using relatively new techniques in space exploration. The data collected from these occultations improved the precision of previous measurements and produced the first recorded evidence of an abnormality in Lanzia. In future observations of other asteroids, we can apply occultation techniques to discover further abnormalities.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH

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☐ vertebrate animals ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 233 | PS | 6004 |

**Title:** Bird Identification Software Using Python and Keras CNN

**Student Name(s):** l. lapierre


**Abstract:**

Bird watching is a popular hobby among many but being able to identify birds out in the field or from a picture can be challenging for those with less experience. The goal of this project is to design a bird identification software using a deep learning model called a convolution neural network or CNN. This software will allow the user to input a photo of a bird and have the software output the name of that specific bird. The convolution neural network will be designed in Python along with the Keras deep learning library. A dataset of images made by Caltech which has images of 200 bird species will be used to train, evaluate, and test the software. All images were resized to have the same dimension before passing them through the model. The model designed for this project has three convolution layers, one hidden layer and one output layer. After the validation images were passed through the network a final accuracy of 53% was reached. The test accuracy reached 98%. Further iterations of the model were done to improve accuracy and the highest validation accuracy achieved was 61%. These results indicate that the model overfit the training data causing it to do not as well on the validation images. In the future, transfer learning will be explored as an alternative way of making a CNN as opposed to training one from scratch.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 250 | PS | 6005 |

**Title:** Accessible program and system to accurately align a star tracking mount using a DSLR camera.

**Student Name(s):** S. Staubly

**Abstract:**

Astrophotography is a widely popular hobby involving taking pictures of faint star formations in the night sky. Most amateur astrophotographers purchase a star tracking mount for their DSLR camera so they can take longer exposures of these stars while minimizing star trails which form in the picture due to the Earth's rotation. The downside of these mounts is that the longer one wants to expose an image while eliminating star trails, the more accurately they must align their mount with the North Celestial Pole (NCP). The most accurate method is with the use of an electronic polar scope, which connects to a computer program allowing for very accurate alignment. The downside is the scope has no other uses besides polar alignment, so spending an additional $300 on an extra camera for one single purpose is wasteful when one could seemingly use their DSLR camera for the same purpose. This project will investigate the ability to use a DSLR camera for polar aligning the star tracking mount. The goal is to achieve a similar accuracy and efficiency as an electronic polar scope, without requiring the purchase of extra equipment. A program will be written to receive images from a Nikon DSLR camera, perform necessary calculations, and provide a simple guide showing the user how to obtain a perfect alignment. Future applications of this project allow for a wider audience to utilize their DSLR cameras to obtain a precise alignment while saving money for future purchases to explore their hobby even further.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 243 | PS | 6007 |

**Title:** Utilization of Self- Sanitizing Hydraulic Arm for Reduction of Illness Transmission

**Student Name(s):** H. Young

**Abstract:**

The purpose of this project was to investigate and develop a method in which contact can be reduced between cashiers and customers in a retail or grocery store setting. The device constructed is designated to decrease risk of exposure for frontline workers, derived from the need for increased safety during the ongoing COVID-19 pandemic. In doing so, preliminary research was conducted pertaining to illness transmission, including sanitization methods of certain materials as well as the role of distance and physical contact in risk of infection. I then constructed a hydraulic powered mechanical arm that transfers money and sanitizes surfaces as well as non-porous payment methods, to minimize contact between cashiers and customers. A syringe stand was also assembled for efficient functioning of movement as well as a hydraulic powered sanitization stand, to disinfect items in contact. After the completion of construction, the testing trials successfully proved the arm was able to rotate the intended degrees through use of syringes and tubing attached. The sanitization stand also accurately functioned through outputting cleaning spray when intended. While the construction of this device was primarily to perform the intended function, some further investigations I intend to pursue would be to revise the arm, syringe holder, and sanitization stand to develop a more streamlined and sleek design. This hydraulic arm can be implemented in super markets and other retail businesses in which cashiers are engaging with customers, to ensure social distancing and reduction of transmission.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE EN ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 249 | PS | 6008 |

**Title:** Using Fractal Metamaterials with Non-Integer Dimensionality to Manipulate the Propagation of Acoustic Waves

**Student Name(s):** N. Shell

**Abstract:**

A "metamaterial" is an engineered structure whose properties are determined by its macroscopic geometry, rather than its microscopic constituent materials. Metamaterials are used to manipulate waves – light, sound, or even seismic waves – in ways that may be impossible in naturally-occurring materials. However, existing metamaterials have limited bandwidth – they function only within a small frequency range, determined by their fixed geometric length scales. I simulated "fractal" metamaterials, to investigate whether the cascading length scales of a fractal can increase the functional bandwidth. Specifically, I investigated whether a Sierpiński triangle – a set of self-similar triangles of ever-decreasing lengths – can provide acoustic isolation over a larger frequency range than a simple triangle. [I optimized the acoustic band gaps – frequency ranges in which sound cannot propagate due to the structure of the metamaterial.] I used the finite-element analysis software COMSOL to simulate Sierpiński triangles of orders n = 2, 3, and 4, extruded from a 2D plane and built in 3D space. I simulated a 5-cm structure made of the plastic PLA (polylactic acid), which could be 3D-printed at low cost. I calculated the amplitude of sound transmission through the Sierpiński metamaterials over a range of frequencies from 0-20 kHz, and found a shift of the transmission spectrum to higher frequencies as the fractal order increased, as would be expected from the decreasing length scales, available to trap higher frequency sound. These expanded frequency scales may be useful for soundproofing applications, enabling the operation of sensitive scientific instruments.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN AT CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 244 | PS | 6009 |

**Title:** An Algorithm for Object Detection and Avoidance in Drones

**Student Name(s):** W. Wei

**Abstract:**

In recent years, the development of UAV (Unmanned Aerial Vehicle) or drones are becoming more popular with more applications including in military, industry, and entertainment. Drones can also be used in Drone swarming which is a system where a swarm of drones communicate with each other in flight and make decisions autonomously as a single unit; however, one large difficulty for drone swarms is object detection and avoiding the object in an organized manner. The purpose of this project was to create an effective method in order to determine and orderly avoid an object ahead of the drone swarm so drone swarms can navigate through more situations and locations than just in open air. The minimum requirements for this project was for the drones to be able to identify objects and coordinate paths around the object in simulations. The limitations to this project were the amount of drones so the scalability can not be tested. The solution used a Conflict based search algorithm. In order to complete this project, a drone simulation program was needed. The drones and the research platform is at Sacred Heart University's MakerSpace and they were used under the supervision and guidance of Professor Tolga. It was found that the solution was effective in directing the drone swarm to the target location With this algorithm, drone swarms can go into more terrains and locations to reach its goal, which will increase the areas which the drone swarms can be useful.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☒ Yes ☐ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 247 | PS | 6010 |

**Title:** 2 Speed Mechanical BMX Race Gearbox

**Student Name(s):** J. Hatt


**Abstract:**

BMX racing is a one lap sprint race on a single speed bike that runs an optimized gear that works for the whole track. A higher gear ratio is slower out of the start, but allows for higher top speed, while lower gear ratios are fast out of the start, but don't have as much top end speed. Some riders are able to spin their legs fast enough to keep building speed with low gearing, but not all riders are able to do this.

To solve this issue, I designed and fabricated a prototype two speed gearbox. The gearbox has a low gear, for fast acceleration off the start, and a higher gear for more top end for the remainder of the race. Eventually when it's fitted to a bike the rider would select their gear by use of handlebar mounted shifter, cable, and linkage. After assembling the gearbox, I fabricated a stand to test my prototype. During testing I rotated the cranks in each gear ratio. To verify gearing accuracy, I used scribe lines on the chainring spider and crank arm. I found that everything was accurate.

Due to weather and my mentors availability I wasn't able to fabricate a bike frame to test. I believe it will function as expected based on my prototype testing. In future refinements, I would use aluminum for some parts to reduce weight, redesign the selector hub for improved engagement, and would use gears instead of chains to reduce drag.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 242 | PS | 6011 |

**Title:** Muscular Strength and Endurance Adaptations Following Resistance Training Using Higher Volume and Lower Intensity or Higher Intensity and Lower Volume

**Student Name(s):** C. Shea


**Abstract:**

When it comes to resistance training, whether or not one should prioritize training volume or training intensity when trying to optimize their muscular strength and endurance is relatively unclear. The literature on this topic comparing different training intensities either didn't take training volume into account at all or did but could have made more of a distinct difference in volume between both groups to better compare training intensity vs. training volume. Therefore, experiments were set- up so that there is more of a distinct difference in volume between both groups, with the higher intensity group training with half as much volume as the lower intensity group to give more of an honest evaluation for which one could be more beneficial to prioritize. A control group and two training groups were tested with their one rep maxes (1RM) and a max rep out of 50% of their 1RM on the barbell shoulder press and barbell row initially and then 8 weeks later. The total pounds of increase of the subjects 1RM will be measured along with the total reps of increase of half of the subjects initial 1RM and standard deviation of both measurable will be determined for each group. It is expected the higher intensity and lower volume group to show greater pounds of increase of their 1 rep maxes, but for the lower intensity and higher volume group to show greater reps of an increase of half of their initial 1RM.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ME MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 236 | PS | 6012 |

**Title:** Modular Robotic System for Multipurpose Robots

**Student Name(s):** B. Ochs

**Abstract:**

Currently there are robotic systems that replace human first responders, but they have only one specific use. This project will design a robotic system that will demonstrate the ability to replace first responders in a dangerous situation, no matter what the situation is by being modular. A possible solution to a modular robot will be designed, developed, and a small scale, 3D printed prototype will be built. It would use very similar electronics to a proper, fully-functional robot, but it will only have basic functionality as its primary goal is to demonstrate modularity. To connect the modules of the robot there will be dedicated high power plugs and a primary plug will carry all data and lower voltages like 3.3V and 5V. To prove that the modularity works properly, multiple modules will be made and be tested for their ability to connect to the robot and interchange with each other. The current basic tests have given promising results. A central computer is able to communicate with external microcontrollers simulating a module. The programming of more simulated modules is planned and construction of housings for the computers is in development. The method of communications used is favorable for these applications, as it is easy to use and only requires two data lines. The concept of using a standard connector to carry these signals has also been tested and should not cause any problems later in development.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE AT CS

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 219 | PS | 6013 |

**Title:** Unveiling Lost Galaxies: Studying the hidden galaxies of 2175 Å dust absorbers

**Student Name(s):** B. Wang

**Abstract:**

I report the discovery of four host galaxies of 2175 Å quasar dust absorbers at the redshifts around 1 in the early universe (about 8 billion years ago, the universe is 13.7 billion years old), the second host galaxy ever discovered among very rare quasar dust absorbers and the first discovered using a ground-based telescope. These host galaxies are toward the background quasars SDSS J081738.34+433303.6, J113608.50+514754.0, J074259.57 +225003.3, and J100713+285348 and were discovered using the world's largest ground-based telescope, the 10.4 meter Gran Telescopo Canaris Osiris RTF and traditional PSF subtracting techniques. The impact parameter for each quasar range from 0.36 to 18.79 kpc with a magnitude ranging from 21.04 - 23.02 AB. These measurements show that dust absorbers have much smaller impact parameters than other quasar absorbers such as Mg II absorbers and damped Lyman Alpha absorbers, supporting that the host galaxies of these 2175 Å quasar dust absorbers are associated with disk components. Therefore, these dust absorber galaxies can be used to trace the evolution of galaxies similar to the Milky Way galaxy which is dominated by disk components. The discovery was then confirmed by ensuring an accurate PSF. This revelation paves the way for more discoveries of host galaxies providing greater insight to understanding the formation and evolution of the Milky Way.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 177 | PS | 6014 |

**Title:** Renewable Energy: Converting Vibrational Motion from a Bridge into Electrical

**Student Name(s):** N. Muriel


**Abstract:**

Due to the detrimental effects of fossil fuels as our current energy sources, I decided to do a project in the realm of renewable clean energy. In this project I created a parallel circuit with piezoelectric transducers to collect electrical energy from vibrational motion in a model bridge. The goal was to create this and collect at least 1 volt of energy. A 2 ft tall model bridge was built with the help of a carpenter. Mini cubes made from cardboard with piezoelectric transducers were attached and connected to the bridge, then connected to a circuit with an AC/DC converter to an electrical multitester. The testing was done by shaking the bridge left and right in a uniform motion. Each side was tested 5 times for 3 different times 5 sec, 10 sec, and 15 sec. The design goal of 1 volt was achieved in the collective energy from all three cubes for 15 seconds which was 1.4028 V. The Sides parallel to the beams of the bridge, sides B and D, generated the most energy.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE ET

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 248 | PS | 6015 |

**Title:** Design Study: Downsizing Nuclear Fusion Devices to a More Manageable Scale

**Student Name(s):** J. Amara

**Abstract:**

In the modern process of developing nuclear fusion for the purposes of energy production, a common issue is overlooked when trying to test the limits of nuclear fusion. The primary issue with most forms of fusion reactors is that they are too large and take years to construct even the facility to house them. There has to be a way to take that concept of fusion and strip it down to its bare bones to where it doesn't have the fancy features like the JET or ITER. With a smaller reactor, it'll be easier to control and easier to manufacture and spread across the world. The only problem with fusion is not the reactor itself, but again the facilities to house them. These specialized facilities need turbines which are spun by the reactor's exhaust steam. By taking the initial design of a tokamak and bringing it to the scale of a car for reference, reactors could be loaded onto trucks which could someday supply towns with their own energy eliminating the need for statewide energy grids which will cut costs on maintenance. This will be done by creating a design using an Auto CAD program which will serve as a template for further streamline. The initial model will take the concept of a large scale reactor and strip it down to the most basic components needed to achieve fusion, which will then be improved upon overtime as fusion technology develops. This project aims to create that initial design.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH ET CH

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 251 | PS | 6016 |

**Title:** Harnessing Bio-Kinetic Energy Through A Wearable Non-Invasive Generator

**Student Name(s):** A. Vassallo

**Abstract:**

Biokinetic energy is currently an overlooked/undervalued method for the generation of electricity. It is proposed that biokinetic energy produced through human body movement can be harnessed for electrical generation. To accomplish this goal, a set of retractable cables are connected to direct current generators, which are wired in series, using 6MΩ wire, on a breadboard. The breadboard forms a circuit which outputs into a portable power bank. The retractable cables then run through silicone tubing to prevent wear and are attached to each hand and foot. As the arms and legs move, actuating the cables, which then spin the pulleys through 3D printed cams attached to each generator. Being DC generators, a diode is wired on the positive lead on the output wire to the power bank to prevent the reverse flow of energy. Solar cells are added to compensate for stationery periods and increase electrical output potential. All the generation/control components are then held in a foam padded, hard carry case that can be worn as a backpack. The rate at which the power bank charges will vary on the movement speed of the individual wearing the device. The average power output is 0.8 Amps (A). To put it into perspective, a typical 110 Volt charging block outputs 2A of power. Based on this output data this novel device will successively serve small portable electronic devices in multi-faceted applications for civilian and government sectors. Further research will be required to directly integrate this technology into clothing garments.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE ET

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 232 | PS | 6017 |

**Title:** The Impact of Temperature on Blood Vessel Dilation

**Student Name(s):** A. Skrabacz

**Abstract:**

A recent poll revealed that roughly 90% of student athletes have had a sports-related injury. Another poll showed that roughly 54% of student athletes have played while injured (Justin Weinstein, April 17, 2020). This raises the question of how many of those injuries could have been prevented, treated, or healed with a simple ice pack or heating pad. This experiment explored the relationship between blood vessels and temperature, to further understand what icing and heating do to the blood vessels while healing injuries. Blood vessels bring oxygen, nutrients, and blood to the body, making them vital for survival and extremely important to understand and observe. To explore this relationship, scientific models of blood vessels were made out of latex gloves filled with water. These models had their starting volumes taken using a water displacement method then, had ice and heat applied to them, and finally they had their ending volumes taken. With the data gathered from the experiment, a line graph was made that showed the relationship between blood vessel dilation and temperature. The data supported the hypothesis that an increase in temperature will cause an increase in dilation, and a decrease in temperature will cause a decrease in dilation. Understanding icing and heating methods and what happens in the body while doing so, is necessary for coaches and athletes especially, to prevent further injuries and help to heal current ones.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ME BE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 277 | PS | 6018 |

**Title:** Eco-friendly Remediation of Arsenic and Phosphates from Contaminated Water Resources Using Iron Fortified Spinach Roots and Biochar

**Student Name(s):** E. Wallace


**Abstract:**

Increased industrialization continues to release many pollutants, including arsenic and phosphates, into groundwater resources. A simple, effective and easily-constructed filtration system is needed to remove both contaminants, particularly where potable water is scarce. Recent research has highlighted the use of iron as an arsenic-absorbent via unique electrostatic interactions, however its preparation is difficult. Iron's absorbance of soluble phosphates remains uninvestigated. Herein, a simple filtration column was designed from common materials (sand, gravel, and biochar), along with Fe+3-fortified spinach root (FeSR). To create FeSR, 2.5grams chopped-SR was added to 250ml 0.1M FeCl3, stirred overnight, and adjusted to pH=5 to facilitate stronger adsorption of As(V)/As(III). A filter-system was constructed in a 2.5x30cm borosilicate tube, to facilitate contaminant-medium interaction, in the following top-bottom order: sand-FeSR-sand-biochar-gravel (15:1:5:1.5:15 m/m). Following, 50ml of 100ppb As and 10ppm PO4-3 were separately passed through the filter column (~50ml/min). ICP analysis confirms removal of ~90% As in one filter pass to 10.2ppb, well below the EPA water action level of 15ppb. Continued filtration (5-passes) reduces As to 0.42ppb. For phosphates, 2-filtration passes were required to reduce the contaminant below the 25ppb EPA-WAL, to 3.6ppb, and 1.4ppb in 5-passes. Filtration with a FeSR-free column reduced As and PO4-3 to 74.2ppb and 703ppb respectively, further highlighting FeSR's absorbent nature. FTIR analyses of all filtrates demonstrate that they are free of filter-column materials. SEM/EDS analyses of the post-filtration column materials further highlight FeSR and biochar's affinity for both contaminants, and confirm the efficiency of the column construction for complete removal of As/PO4-3.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project):** EM BI EV

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☒ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 251 | PS | 6019 |

**Title:** Yielding High Value Secondary Products from Fossil Fuel Waste Utilizing Electrolysis

**Student Name(s):** D. Steer

**Abstract:**

Currently there is a large problem with the wasting of resources when it comes to the treatment of coal fly ash. With the use of electrolysis on a coal fly ash solution, aluminum can be sequestered from the material as well as other high-value byproducts. Using electrolysis to separate aluminum from coal fly ash could become a major source for the metal. The goal of the project are to develop a cost-effective and efficient way to obtain aluminum with electrolysis. The project is being completed with the use of an x-ray spectrometer to determine and analyze the yields of the electrolysis reaction with the coal fly ash. The electrolysis reaction is being completed with the use of a low voltage power supply that electrifies the solution. Aluminum is being reclaimed from the coal fly ash. With current data collected over many months of experimentation it seems that there is some alumina that is being separated from the coal fly ash, but at a very small efficiency. However, there is a large amount of silica and other materials that are being separated from the coal fly ash through electrolysis. Future implications that this project could have would include new ways of production for the world's most highly demanded metals and the efficient production of other materials that may be difficult to produce as of now. Future research relating to this project could include the uses of different electrolytes and methods in reclaiming these materials from the coal fly ash.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 219 | PS | 6021 |

**Title:** The Fabrication of a Cost-Effective Paper LIB with Increased Voltage and Longevity

**Student Name(s):** J. Rassias

**Abstract:**

The world is in an ever-expanding digital age and revolving around the need for batteries, specifically lithium-ion batteries (LIB) due to their lightweight, small size, and high voltage. However, modern-day LIBs have crucial limitations such as their price, rigid structure, and relatively small range of operative temperatures. The motivation of this investigation is to create an improved, cost-effective, paper LIB while maintaining reasonable power output. This project consists of fabricating a flexible paper LIB with the optimized cathode, anode, and multi-walled carbon nanotube materials. Methods for this study consist of applying a slurry of carbon nanotubes and lithium manganese oxide to a cellulose-based paper. This adhered film acts as the cathode. The same method is applied with lithium titanate oxide for the anode on the opposite side. Voltage, current, and resistance will be measured with a multimeter as well as changes within the battery during charge and discharge. Current voltages are measuring 0.5 Volts and improving. Also, multiple batteries can be connected in series to achieve an increased voltage. Implications for this study are the larger range of operative temperatures and the low price (currently under 3 dollars). Also, the battery is more flexible (due to the paper separator), which allows for a variety of uses such as wearable electronics and medical applications.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE CH AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☒ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 187 | PS | 6022 |

**Title:** Incorporating Pre-Game Rankings to Colley, Massey, and Elo Methods

**Student Name(s):** J. Liu

**Abstract:**

Colley, Massey, and Elo are three popular rating methods commonly used in the NFL and Major Division I NCAA sports where game results from the regular seasons can be used to seed major playoff brackets or create predictive rankings. As with most rating systems, an ample amount of game data is needed for the resulting rankings to be reflective of the competitors' strength relative to others. However, in situations such as a professional golf match play tournament, where there is a lack of available match play data, or initial weeks into regular NFL season, when it is too early to have the appropriate amount of needed data in hand, how can we produce rankings that meet the standard of accuracy? To address this problem, this project proposes two possible seeding methods, the dominance graph method and the weak dominance graph method, that both incorporate pre-game rankings to make up for the lack of relevant games that are adaptive to Colley, Massey, and Elo. In predicting the outcomes of the Dell Technologies Match Play and weekly NFL games outcomes, the effectiveness of the method can be tested.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** MA CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 244 | PS | 6023 |

**Title:** Improving and Designing Renewable Technology... even when the sun doesn't shine

**Student Name(s):** M. Neiss


**Abstract:**

In recent decades, human activity has caused significant carbon dioxide buildup in our atmosphere and is negatively impacting Earth's climate. Renewable technology such as solar panels, wind turbines, and hydro-electric dams have been developed to minimize our carbon footprint. However, current clean energy harvesters all have common deficiencies; all depend on weather conditions and are unreliable.

This project seeks to improve the design and efficiency of existing energy harvesting systems to generate electricity with less dependency on weather. My analysis includes the average energy production and consistency of the harvester, along with size, environment impact, and lifespan. The result is a harvesting system, capturing energy from ocean waves and direct sunlight.

Average 10kW solar panel systems, costing $20,000, have the smallest footprint and the highest energy conversion. Wind turbines with a capacity of 2,000-3,000 kW cost $2.6-$4 million. Although wind turbines are cheaper per kW and have an extensive lifespan, their average energy conversion efficiency is 30%-40%. While hydroelectric dams are the most consistent energy harvesters --producing 1,000-10,000 kW--, their costs soar as high as $4,500/kW and have a large impact on the environment.

After developing many CAD sketches, my final design is a multi-harvester system that includes 3 PowerBuoys© joined through a main structure, three 10 kW solar panel networks integrated on "wings" enabling optimal direction toward the sun, and storage capacity ranging from 50-150 kWh. Each PowerBuoy© is capable of producing 8.4 kWh on an average day.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ET EE EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 253 | PS | 6024 |

**Title:** Development of a Low-Cost, Expandable Boot Aimed to Adjust to Multiple Sizes and Last Multiple Years

**Student Name(s):** A. Chalasani

**Abstract:**

783 million people are forced to live off of $1.90 per day. There are only three expandable footwears currently being sold-all with prices out of the price range of the millions stuck in poverty. Plus, there are no expandable boots being sold for either men or children. This project's purpose is to develop a durable, waterproof boot expandable up to four sizes and affordable for those impoverished. In the previous year, a design was created for a full-coverage shoe expandable up to three sizes larger than its original size and with an estimated total material cost of $23.96. To build upon this past project, this year the student enhanced last year's model by lowering the production cost and making it waterproof. After an extensive trial and error period, materials totaling under $26.23 and a design based off of that of the previous year were determined. Then, a final technical drawing and 3D model run through a finite element analysis program were developed. The student 3D printed a prototype of the determined outsole structure. Design thus far supports the intended goal. These boots will allow those poverty-stricken to safely walk to daily tasks in areas without paved roads. For adults suffering from conditions such as edema, this boot can provide comfort. Also, for those unable to afford a college degree and turning to blue-collar jobs, the expandable boots will provide them with greater coverage and durability, allowing them to work safely in work areas often filled with debris, mud, etc.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN AT EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 224 | PS | 6025 |

**Title:** The Manufacture and Performance Evaluation of a Locking Container to Eliminate the Distraction of Phones While Driving

**Student Name(s):** S. Lowder


**Abstract:**

With the rise of technological advances in the 21st century resulting in the popularity of cellular

devices, car accidents, and fatalities associated with distracted driving have become an increasing issue of concern. Additionally, young people are more likely to use their phones compared to older individuals, which makes them a safety concern for their early years as new drivers. To restrain individuals from phones, a prototype for a locking container was developed during freshman year requiring the driver's phone to be stored within the container before driving to prevent attempts of distraction. Afterward, my sophomore year focused on manufacturing a 3D model and PCB boards for the project. Therefore, for this year, the focus was on implementing and testing the performance of the product in an automobile for real-life application and performance evaluation. During testing to ensure successful performance evaluation, trials such as testing the effectiveness at preventing user tampering, as well as finding the best location for implementation of the product is tested. Concerning the purpose of the product, the main implication is to prevent future teen driving-related car crashes involving the distraction from their cellular device and save lives. Other potential implications for this project can be for personal safety for any driver, or as a business policy for the safety of workers for companies such as FedEx or UPS.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 244 | PS | 6026 |

**Title:** The Effect of Ocean Acidification on Chlorophyll a Concentration and the Net Primary Productivity of Tetraselmis Phytoplankton

**Student Name(s):** L. Nelson

**Abstract:**

Carbon sequestration by phytoplankton is a natural process with potential to mitigate the effects of excess atmospheric and oceanic carbon dioxide as the climate crisis progresses. The purpose of this investigation was to evaluate the effect of reduced pH on the net primary productivity (NPP) of phytoplankton as indicated by chlorophyll a concentration in order to determine phytoplankton's ability to absorb carbon dioxide under increasingly acidic conditions. This research builds on previous work by focusing on chlorophyll a as an indicator of NPP, using a controlled lab environment, and considering a pH range specific to ocean acidification projections. In the lab, phytoplankton were grown using a live Tetraselmis culture, divided into five samples, and subjected to different pH values ranging from 8.1 to 7.7. Every 24 hours for a week, chlorophyll was extracted from each sample via vacuum filtration methods and measured using spectrophotometry at two wavelengths: 645 and 665 nm. Chlorophyll a concentrations could then be calculated from absorbance ratings. The data collected during this experiment demonstrates a decrease in average chlorophyll a concentration as pH decreases, therefore indicating a simultaneous decrease in NPP. Since depth was controlled in this experiment, the production per unit chlorophyll concentration was constant, and NPP and chlorophyll a concentration are directly proportional. These results reveal that lower oceanic pH will affect phytoplankton carbon sequestration as ocean acidification continues. Understanding the future productivity of phytoplankton provides context for climate change projections and the future health of marine ecosystems.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EV EA CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 250 | PS | 6027 |

**Title:** Project Regrow: Cutting-Edge Technology to Fight Deforestation

**Student Name(s):** S. Bhardwaj

**Abstract:**

In the 2020 wildfire season alone, the California Department of Forestry and Fire Protection projected 4,197,628 total acres of land were burned throughout California, ravaging countless forests and wildlife. These devastating wildfires have been drastically affecting wildlife for generations and have been adding to the fast-growing issue of climate change. Project Regrow intends to alleviate this fast-growing problem. Project Regrow intends to protect, preserve, and grow the world's forests by using drone technology to plant seeds. The drone itself can be filled with seeds, and flown over the desired area for regrowth.

Project Regrow utilizes a 3D printed skeleton, housing the Raspberry Pi Zero W, a battery pack, a seed container, and a seed disperser to disseminate seeds. The 3D printed skeleton can be mounted onto any drone that is at least 36 millimeters wide and 31 millimeters tall with the use of Velcro straps to secure it. The seed disperser opens and closes to drop the seeds from the attached container by using a servo motor. The servo motor is connected to the Raspberry Pi Zero W, which is programmed in Python to open and close the shutter every 2 seconds, which gives enough time for the seeds to disperse. This process also saves enough seeds in the container to maximize the area for the seeds to be planted. To prevent excess seeds from being dispersed, an adapter between the seed disperser and the seed container was made. More development is necessary to ensure full forest revitalization.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT EE CS

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 228 | PS | 6028 |

**Title:** Thermoelectric heating and cooling of an electric vehicle utilizing phase change material.

**Student Name(s):** A. Nomani

**Abstract:**

My project aims at trying to increase the driving range of an electric vehicle by creating a new Air conditioning system that does not draw as much energy from the battery when operating. We are proposing the use of a thermal battery that can provide hot and cold air to the cabin. The thermal battery utilizes phase change material in order to store thermal energy. When this phase change material is exposed to a certain temperature it melts and releases cold air. Air is brought in from outside and is blowed in the thermal battery to melt the phase change material. In order to heat the cabin the phase change material is cooled by the Peltier module and releases heat as this occurs. In addition to the fact that the air conditioning system does not extract as much power from the electric battery, it is also lighter than the traditional air conditioning system. This means that there is less weight on the electric vehicle and for the same amount of power the vehicle will go further. This results in an additional increase in the driving range. In conclusion, we are trying to increase the driving range of an electric vehicle so that it becomes more appealing to potential customers. If more electric vehicles are used in the world this will help resolve the issue of global warming.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE EN ET

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 190 | PS | 6029 |

**Title:** How Do Different Environmentally Friendly Aggregates Affect The Bearing Strength of Concrete

**Student Name(s):** P. Danise

**Abstract:**

The goal of my experiment was to find a suitable, environmentally friendly aggregate to replace gravel in concrete. For my experiment I conducted testing on 5 different aggregates: plastic, paper, rubber, glass, and concrete debris. I conducted my research on the bearing strength of concrete with each of the aggregates. To make my concrete, I used 2 parts portland cement, 2 parts sand, 3 parts aggregate, and 3/2 parts water. I put these mixtures into rectangular molds with the dimensions of 3.125 x 1.5625 x 0.3125 inches. I made 6 molds of each mixture and tested them each by placing the mold horizontally with both sides being supported by tables. I then took a bucket and tied it over the mold. To start testing I placed weights in the bucket until the sample broke. I recorded the breaking weight for each of the 30 samples tested. For the samples with plastic as the aggregate the mean breaking weight was 35.33 lbs, paper was 56.67 lbs, rubber 22.17 lbs, glass 34.17 lbs, and concrete debris 42.5 lbs. To conclude, my project found that paper was the strongest environmentally friendly aggregate tested.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN EV EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 212 | PS | 6031 |

**Title:** Absorbent/Refrigerant Pairs used for Heat Pumps and Heat Rejection Technology on Spacecraft.

**Student Name(s):** C. Riley

**Abstract:**

Heat is a major problem for spacecraft, as most of the ways currently known for transporting heat do not work in space, as they require a molecule to molecule connection, which would not work in a vacuum environment like space because of the low amount of molecules. This means the only way to transport heat away from spacecraft is through radiation, or the process of turning heat into electromagnetic (EM) waves, and emitting through a radiator. This process is often achieved by using some transportation device that can take the heat, and move it to the radiator. Often, heat pumps are used for this action. Heat pumps have a liquid inside of them, in this paper's case, an absorbent/refrigerant combination, which can take in the heat, and eject the heat when at the designated destination. This paper will show a specific refrigerant, r134a, that will be tested and compared against other common refrigerants, which would be water and ammonia, to see their abilities to hold and transport heat. This will be done by testing the vapor pressures of the refrigerants at fixed temperatures between 0 and 40 degrees Celsius. The conclusions will show if r134a is more efficient at transporting heat through a heat rejection system than the other common refrigerants.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

- ☐ human subjects
- ☐ potentially hazardous biological agents
- ☐ vertebrate animals
- ☒ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 255 | PS | 6032 |

**Title:** Gravity-Assisted Energy Conversion: Improving the Feasibility of Mechanically Powered Electricity Generators

**Student Name(s):** A. Anuar

**Abstract:**

As technocentric populations expand and global industries progress, there grows an increasing demand for research into methods of generating and storing energy. The refinement of new methods of energy conversion will lead to sustainable technological practices and reduce the impacts of wasteful energy consumption on an individual and macroscopic scale.

Current methods, such as wind or hydro power, utilize generators to convert mechanical work to electrical energy. These generators will be the focus of this engineering project: weight-powered mechanisms utilize gravity as a driving force by converting potential energy to other types of energy. Other quasi-perpetuation mechanisms, such as escapement mechanisms found in watches or pendulums used in grandfather clocks, are useful for extending the duration of the activation period of a mechanism.

Thus, the goal of this research is to maximize both the intensity and duration of gravity-powered electricity generators, by trying to compound weighted mechanisms and duration-extending mechanisms. A 3D printed escapement mechanism was mounted onto the shaft of a generator and several alterations were made to the mechanism to improve the quality of the mechanism.

The experimental mechanism failed to perform either of its intended improvements in duration or intensity, regardless of changes made to either component. It is hypothesized that the weighted mechanism's intensity acted in counter to the escapement mechanism's duration extension. Further studies into "gravity power" should study alternative duration-extending mechanisms such as constant force springs that may avoid this counteraction within the compound mechanisms while improving the efficiency of weight-powered energy generation.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ET EE AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 214 | PS | 6034 |

**Title:** Designing a Data-collecting Robotic System to Help Negate the Effects of Eutrophication

**Student Name(s):** R. Kulsakdinun

**Abstract:**

The purpose of this project was to design a solar-powered robot that measures multiple parameters of water quality in order to make data readily accessible for the detection of eutrophication. The robot was created in two main steps: designing the software and designing the robot's exterior. The design of the software took place in three parts. First, code had to be written for the Arduino in order to have the temperature, pH, turbidity, and dissolved oxygen sensors return data. Then, code for the timing circuit was written, in which a DS3231 real-time clock was used to externally wake up the Arduino every two hours. Lastly, the sensor data was sent from the Arduino via LoRa and displayed on a Thingspeak dashboard. A solar-charged 3.7 v lithium-ion battery along with a voltage booster allows the robot to remain outside indefinitely and provide continuous data. The electronics were housed in a waterproof plastic box, which was put inside a second box. The 3d-printed tube that contained all the sensors protruded from the bottom of this outer box. Finally, this structure was placed on a buoy ring. Initial trials determined that the robotic system succeeded in its task of autonomously providing continuous, in-situ water data and making that data easily accessible.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE EV AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 255 | PS | 6035 |

**Title:** How Holidays Impacted the Spread of COVID-19 in the United States: An Exploratory Analysis

**Student Name(s):** J. Li


**Abstract:**

COVID-19 has become a national crisis in the U.S. Holidays could be a risk to cause super-spreading. However, the extent of the impact from holidays remains a question.

My research questions include: whether holidays triggered COVID-19 surges; whether different holidays impacted differently; whether different states were affected the same. Easter, Memorial Day, Independence Day, Labor Day, Halloween, Thanksgiving, and Christmas and New Year were selected for study. I used data from the Johns Hopkins Database on GitHub. I compared the weekly COVID-19 cases before and after each holiday using the absolute difference and ratio, for the entire country and for the top states with the most and least cases up to date.

Results show the most influential holidays nationwide were Independence Day, Halloween, and Thanksgiving. The second week after the holiday was worsening than the first week. The greatest surge was from the second week after Halloween, where cases nearly doubled with an increase of half million from before. Furthermore, Halloween was the only holiday after which every state increased, even including the five states with the least cumulative cases.

Different states were impacted differently. California was hit most heavily during Independence Day, where cases increased by about 150%, and Thanksgiving, where cases increased by 233% 2 weeks after. Florida showed the greatest relative change during the second week after Memorial Day when cases increased by 1.5 times.

Results show that not every holiday has the same impact on outbreaks of COVID-19. My findings provide insights to guide holidays restrictions.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** MA BE ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 196 | PS | 6037 |

**Title:** Designing a Novel Social Distancing Device

**Student Name(s):** S. Viswanathan


**Abstract:**

In order to control the COVID-19 pandemic, the CDC has recommended social distancing to prevent the spread of infections. The objective of this project was to create a social interaction monitor (SIM), a device that in combination with a mobile application would help people maintain social distancing and record infractions. Phase one of this project was to design a portable SIM that would alert the user if they happen to come within six feet of another person carrying a Bluetooth device like a cellphone, smartwatch, laptop, or another SIM. Phase two, which is still in progress, is to create an app that works alongside the device to collect information of persons coming in close proximity and store it in a database. The pocket-sized prototype SIM was successfully developed and tested which functioned as per desired parameters. This SIM can be potentially distributed as is to crowded situations such as schools, colleges, and workplaces and could help reduce the rapid spread of COVID-19. Even though vaccines are being rolled out, not all people will be able to receive them immediately, there will likely be a need for social distancing for the next several months.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT ME EE

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 248 | PS | 6039 |

**Title:** Creating a Smaller and More Portable Vertical Axis Wind Turbine to Increase Accessibility and Usage of Wind Energy Harvesting Devices

**Student Name(s):** B. Lu

**Abstract:**

Wind energy harvesting is a promising form of clean, renewable energy that is held back by the limited applicability and versatility of most common wind turbines. The purpose of this project is to create a smaller wind turbine that is portable and easier to use than existing models and explore the possibility of using smaller, vertical axis turbines in places where traditional models wouldn't work.

Several turbine designs were reviewed during planning. The constructed prototype had to fit the limited size and weight parameters while producing enough power for minor tasks. The H-Darrieus vertical axis model was chosen for efficiency while being easier to manipulate into a portable device. The device was tested in a closed hallway using a leaf blower at various distances to simulate different wind speeds.

The turbine's volume was less than a square meter, which was reduced by half when folded. A maximum output of over 3W was produced in the relatively calm wind conditions used for testing. Power output was limited by the usage of a weaker motor, due to material accessibility limitations.

The foldability of the device successfully increased its portability without interfering with efficacy. The power output was able to reach previously established experimental goals of 2-4 W, which is roughly the power required to charge a phone. In general, proof of concept for the capabilities of a smaller, foldable vertical axis turbine was achieved because the tested model was able to produce usable amounts of power in realistic conditions.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE EM AT

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 262 | PS | 6040 |

**Title:** Increasing Aerofoil Lift via Artificial Amplification of the Coanda Effect using Heat

**Student Name(s):** T. Drinkall

**Abstract:**

The Coanda Effect is the tendency of fluid air molecules to remain attached to a convex surface. This effect is utilized on aerofoils, which rely on the attachment of air across the convex surface to accelerate the upper airflow, creating a pressure imbalance between the high-pressure air underneath the wing and the low-pressure air above the wing. However, the upper boundary layer of air (UBL) generally doesn't remain attached for the majority of the aerofoil surface, generally separating from the wing before reaching the trailing edge. Early UBL detachment results in a gap between the upper and lower boundary layers, forcing high/low-pressure air to mix, creating a turbulent flow of vortices behind the wing (drag). This research investigates the impact of a heated aerofoil surface on the attachment of the UBL to the aerofoil. By constructing a replica of a NACA-4412 civilian-use aerofoil and wind tunnel, the airflow across a wing surface was captured and compared at 10oC and 45oC. The UBL traveling across the heated surface remained attached 28% further than it did when non-heated. Furthermore, the heated aerofoil saw a 64% reduction in the size of the area of drag behind the trailing edge. The significant reduction in drag was determined via a NACA-4412 drag-coefficient/angle-of-attack/boundary-layer separation model. The increase in UBL attachment at 45oC results in a decrease in drag coefficient from 0.6 to 0.2 (67%), decreasing negative acceleration of the aerofoil, thus requiring less thrust output by aircraft and ultimately minimizing fuel consumption in flight.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 251 | PS | 6041 |

**Title:** Designing and Testing an Activated Carbon Cloth Filter to Reduce the Prevalence of Phosphates and Nitrates in the Long Island Sound

**Student Name(s):** A. Barnett

**Abstract:**

Excess amounts of nutrient pollutants enter storm drains and are ultimately directly deposited into the Long Island Sound. These pollutants carry harmful levels of nitrates and phosphates, which cause eutrophication and lead to lower dissolved oxygen levels, also known as hypoxia, which kills fish populations and even entire ecosystems. My previous research has indicated that the carbon cloth filter uniquely decreases both phosphate and nitrate, rather than one of the factors of nutrient pollution, as seen in other filtering materials. The purpose of this year's study is to test the new design of the activated carbon cloth filter in order to replicate my previous research as well as quantify the percent decrease. It is hypothesized that with the introduction of an activated carbon cloth filter nitrate and phosphate levels will be reduced significantly. The effectiveness of the filter was determined by measuring the concentration of these pollutants in the stormwater run-off before and after the use of the carbon cloth filter. A reduction of 100% of nitrates was seen in one trial, and the average decrease of nitrate was 62%. The phosphate levels also decreased by an average of 73%. Based on these results it is expected that by using this carbon cloth filter, strategically placed in storm drains, nutrient pollution will be reduced significantly by a factor of approximately 5%. Nutrient pollution affects thousands of bodies of water across the world and finding a solution to combat nitrate and phosphate overflow will create healthier water for all marine life.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT EN CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 185 | PS | 6042 |

**Title:** Natural Lubricant Substitute for Railroad Applications

**Student Name(s):** D. Boudreau

**Abstract:**

Transporting food, goods, and people by rail is known to be one of the most efficient ways to transport large volumes. Reducing friction in rail would greatly increase fuel economy. This experiment replaces petroleum lubricants with environmentally friendly Deep Eutectic Solvents (DES) and naturally derived lignin from wood pulp; as traditional oils contaminate the surrounding soil. DESs prepared from literature references did not have the same physical properties as referenced. This included a lower solubility of lignin than originally intended. As a result, this required several modifications to the DESs in order to give them appropriate viscosities and consistencies in order to be used as lubricants. Friction was studied using a homemade tribometer built from a bicycle wheel with an initially applied force and monitoring the speed of the wheel using a tachometer and different lubricants. Results showed that unlike literature references, the DESs displayed no friction benefit on their own. The addition of lignin proved that lignin is an efficient friction modifier. Future work is needed to improve its solubility of lignin so that it can be used as an environmentally friendly friction modifier.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN ET EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 253 | PS | 6043 |

**Title:** Using an Automated Drone and Camera System to Improve the Safety of Schools and Other Populated Areas in a Cost Effective Manner

**Student Name(s):** A. Lim

**Abstract:**

The implementation of drones into society has dramatically increased in recent years. One unexplored use for drones is to provide security for public places without placing other lives at risk, especially for areas such as public schools, where, between 1990 and 2012, 215 shootings have occurred across America. To fill this void and reduce the number of shootings, we designed and built a drone using readily purchasable components, such as the ArduPilot Mega 2.8 and an F450 drone frame. Using a camera system we designed, this drone is capable of detecting objects to provide a valid proof-of-concept that such a system can function as intended. Various tests were performed to test the effectiveness of the drone and camera system. The first test measured the drone's battery life and overall flight stability. The camera-and-drone combined system was assessed by recording the consistency of detection for the camera system at varying distances. The tests also examined the overall capabilities of the drone and camera system in clear and windy conditions. They highlighted the drone's minimum and maximum battery life, stability, and the camera system's effectiveness in detecting individuals. The camera had a 100% detection rate up to 4 m, and the drone had a maximum flight time of 22:34 (mins:secs) and 20:21 while using and not using the camera, respectively. This work represents a proof-of-concept that, with additional optimization, will integrate the drone and camera system for the purposes of dramatically improving surveillance and safety on school campuses.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 199 | PS | 6044 |

**Title:** Towards Clean Energy via Radioactivity: An Investigation of the Dissipation of Electrons in an Ultra High Vacuum Environment

**Student Name(s):** L. Apostolides

**Abstract:**

The purpose of this project was to study the dissipation of electrons in an electric field. The analysis of this phenomenon will help study the applicability of free electrons in a vacuum in new fields of clean energy and will help further advance high-energy particle physics research. The project was completed in two main phases. The first step was to find the desirable simulation software and to develop a program written in Python to run the simulation. Pyboltz was selected as a Monte Carlo Simulation, calculating electron transport properties in gas. The software is a cython translation of MagBoltz, a common simulation used at world-renowned facilities such as CERN. The second step of this project involved the implementation of a program written in Python to save and analyze the data, extrapolating results at physically achievable pressures. The velocity as a function of time was calculated by solving a differential equation. By integrating the velocity as a function of time, the distance traveled for a given time can be calculated. Independent of the electric field, the electrons will travel extremely long distances at extremely low pressures that are very difficult to achieve and maintain within a closed system.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH MA EE

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 208 | PS | 6045 |

**Title:** Investigation of Unexplained Intermediate Freeze Point Characteristics as Tested by a Newly Developed Multispectral Optical Biojet Fuel Freeze Point Analyzer

**Student Name(s):** Z. Stevenson

**Abstract:**

The aviation sector contributes approximately 5% of America's total anthropogenic radiative forcing through toxic emissions such as CO2. Fatty Acid Methyl Ester (FAME) biofuels are a promising solution to this issue, although they are very limited in freeze point and cannot withstand the extremely cold conditions of an airplane at cruise altitude. To test the freeze point characteristics of FAME fuel, a multispectral optical biojet fuel freeze point analyzer (comprised of 3 different wavelength emitting LEDs, a multi-spectral photodetector, a PT1000 RTD temperature sensor, and an Arduino Uno microprocessor) has been developed. Throughout preliminary tests, unexplained variations of the light wavelength intensity were observed with different fuel mix ratios. The goal of this research is to better understand the intermediate freeze point characteristics of FAME biofuels and determine the origin of these unexplained variations. To accomplish this, various biofuels will be tested by the optical fuel freeze point analyzer for 3 hours in an auxiliary household freezer. Diesel fuel will also be tested and serve as the control variable. The conclusions drawn from this research may lead to the development of a new optical freeze point device testing standard. This project is still in the development phase, with actual experimentation set to begin on March 10, 2020.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CH

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☐ Yes ☒ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 118 | PS | 6046 |

**Title:** Effect of Electrolysis on Water

**Student Name(s):** A. Pitts


**Abstract:**

This project is on the effect of electrolysis on water that has been contaminated with sodium bicarbonate. This experiment had multiple tests including, Ph and conductivity of distilled water, water with sodium bicarbonate, water that has gone through electrolysis and water with sodium bicarbonate after going through electrolysis. The lowest and therefore least contaminated levels of Ph and conductivity were in the normal distilled water after electrolysis. This means that when looking for a way to decontaminate water, electrolysis is one of the possible solutions. Applications of this idea can be used in water filtration centers. To get even better results you could also use a higher voltage and put the water through a longer period of electrolysis.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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- ☐ vertebrate animals
- ☒ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 236 | PS | 6047 |

**Title:** Artificial Intelligence Medical Question-answering Robot

**Student Name(s):** Y. Qi

**Abstract:**

With the development of the medical system over years, the problem of wasting much time in a line for only a simple diagnosis or match medicine is still unsolved. However, with the development of artificial intelligence, automatically answer questions based on Deep Learning can be accomplished and thus being able to solve the problem. The experiment focuses on the accuracy and loss of the model based on the variety and amount of data under the same epoch size. To process human language, NLP (Natural Language Processing), a field focusing on human language and computer science, can find the keyword among datasets and thus learn therapy from the data about different illnesses and doctor-suggested treatments. By using Transformer model as a basic frame, features of the content of each QA pairs inside the dataset are remembered and the relationships among them are calculated and record. Through the model, the robot can output the match advice under specific conditions based on the questions asked by patients. After experiments on comparing accuracy with different amounts and variety of data, the conclusion confirms that a larger dataset with higher variety provides higher accuracy for the output when the number of training epochs stays the same. Among the five datasets, when the number of epochs is two hundred in the training, the model based on the largest dataset achieves the optimum efficiency - the accuracy is 0.971 while loss is 0.004.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS ME

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 251 | PS | 6048 |

**Title:** The Effect of Various Ammonium Nitrate Concentrations in Phaseolus lunatus to Ameliorate Drought Tolerance

**Student Name(s):** I. Cooper

**Abstract:**

Increasing temperatures in drought-susceptible regions, as a product of climate change, have harmed plants by accelerating rates of transpiration, or the evaporative process of water in plants. The ultimate consequence of increased transpiration in drought areas is the depletion of soil moisture and water in plant tissue, which causes many plants to become dehydrated and die. The experimental response to this issue explores the effectiveness of thermodynamic processes on the reduction of transpiration in Phaseolus lunatus as a means of mitigating the negative effects of climate change in drought-susceptible regions. Over the course of three weeks, Phaseolus lunatus plants were grown in various concentrations of ammonium nitrate and several trials were performed testing pH, presence of ammonium and nitrate ions, rates of transpiration, and temperature. The final experiment utilizes small quantities of ammonium nitrate, and drought conditions are simulated for half of the plants through the use of a heating mat. The same tests will be performed. The increase in concentration is expected to show an inverse relationship with rates of transpiration due to the endothermic reaction caused by the addition with water. Presence of ammonium and nitrate in each sample is expected to remain constant throughout the experiment. These results would provide insight into the development of methods for reducing the effects of climate change by means of allowing plants to gain a resistance to high temperatures and combating the exacerbated evaporation of water in drought areas, thus giving plants the ability to survive in rapidly changing climates.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PS CH EM

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☒ Yes ☐ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 246 | PS | 6050 |

**Title:** System for Underwater Passive Identification of Acoustic Signatures of the Delphinapterus leucas

**Student Name(s):** I. Mendiratta, I. Mendiratta

**Abstract:**

Though there are pre-existing programs utilizing the Fourier Transform to recognize specific vocalizations of bats and aves, there is yet to be such a successful underwater contraption. For species like the Stenella Clymene, a like system which utilizes deep learning to identify and track dolphins based on signature whistle types (SWTs) can provide a currently unknown estimation for the population. Due to limited access to the S. Clymene, initial programming was done based on vocalizations of the Delphinapterus leucas (Beluga whale), acquired from a local marine life reserve. These audios were inputted into a neural net to be broken down by the discrete fourier transform into their wavelengths such that they could be used as the control wavelengths searched for in unclassified audio. The program works by using the Transform to separate audio into its individual wavelengths and then by isolating those deemed important, that is part of a possible S. Clymene audio signature. The goal of developing an AI program equipped to detect specific vocalizations from mixed audio is completed at a rudimentary level, as a foreign D. Leucas audio can be detected based on its similarities to a known and inputted audio - as identified by a neural net. The AI program created can be adapted to account for relative variance in S. Clymene vocalizations. The program can ultimately be applied to provide a new way of monitoring population analysis of marine life, in a larger scheme, specifically including that of the S. Clymene.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS AT EV

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☒ Yes ☐ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 211 | PS | 6051 |

**Title:** Analyzing Manganese Levels in Infant Formulas in Association with the Development of Asthma

**Student Name(s):** J. Liu


**Abstract:**

Manganese is an essential micronutrient that is required for the activity of a varying set of enzymatic proteins. Although necessary for life, an excess amount of manganese has been linked to neurological effects. Thus, maintaining appropriate levels is critical. This raises the concern for current U.S. regulations of manganese levels in infant formula, which were set between 1981 and 2007 - prior to the publications of the much expanding body of research on the neurotoxicity of manganese. The purpose of this research is to analyze the manganese levels in infant formulas in association with the development of asthma. To reach a conclusion, I compiled a list of thorough questions to guide my investigation and cross referenced sources to ensure the validity of my results. I found that current U.S regulations stipulate a minimum of concentration of 5 micrograms per 100 kilocalories but set no maximum limit and that manganese concentrations were 32 to 1,000 times higher in several kinds of infant formulas than levels reported in breast milk. The excess amount of manganese levels in infant formula, among other environmental factors, is a possible cause for the development of asthma. Manganese is an element that belongs to a group of agents called the "transitional metals" that is known to induce occupational asthma.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ME CB

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 251 | PS | 6052 |

**Title:** Creating a distributed denial-of-service attack mitigation system using SYN cookies to ensure access to crucial election information

**Student Name(s):** J. Krukar

**Abstract:**

The need identified for my project is a strong system to protect against cyber attacks, specifically TCP SYN flood attacks, on websites that contain important information for the elections. Around election time, the election may be influenced by data breaches and a lack of accessibility to important information. The most common type of attack is a DDoS attack, a malicious attempt to disrupt the normal traffic of a targeted server by overwhelming it with a flood of Internet traffic. Use of an Anycast DNS ensures that any one of a number of DNS servers can respond to DNS queries, which reduces latency and improves uptime for the DNS resolving service. The criteria of my project is a specific focus on election data protection. Constraints are a short timeline and limited resources. My solution to the identified need was to build a mitigation system using Anycast DNS and SYN cookies to carry out mitigation, which allows the server to quickly filter through the queue. The mitigation system was programmed in C++ then tested against an open-source DDoS attack in Ubuntu Linux employed by Kali Linux. The strength of the mitigation system was analyzed based on the collection of data on how fast it detected and mitigated the DDoS threat. The data suggested that the designed system was stronger and faster than the basic DDoS mitigation system. The system has the potential to be implemented throughout small-server websites throughout the entirety of the Internet to better protect them from DDoS attacks.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 248 | PS | 6053 |

**Title:** Clustering X-ray Absorption Spectra of Catalytic Materials for Energy Applications

**Student Name(s):** J. Russell

**Abstract:**

Roughly 173,000 TW of solar energy reaches Earth's surface as sunlight, thousands of times more than is used worldwide. Moreover, 0.6% of the total land of the U.S. could power the country, and a fraction of the Sahara desert could power the world. Thus, the caveat of solar power is not energy output, but rather conversion and storage, an issue that could be alleviated in part by photocatalysts such as titanium dioxide (TiO2). These catalysts are used not only in the absorption of sunlight, but more importantly in water oxidation and reduction. These processes store energy in the chemical bonds of H2 or H2O2, posing a possible solution to the current deficiencies associated with storing and transporting solar energy. In our study, we examined the crystallization of amorphous TiO2 thin films to the more stable rutile TiO2. The preparation of these films affects crystalline structure and, consequently, catalytic performance. We used clustering, an unsupervised machine learning technique, to efficiently compare the X-ray absorption spectra of various MnTiOx samples, requiring fewer parameters and evaluating structure and function on a broader scale as compared to past studies using supervised learning. By gaining perspective on the structural implications of preparation techniques and their role in crystallization, we can identify the optimal processing conditions to produce materials that capitalize on the stability and versatility of rutile TiO2. Minutia on the molecular scale have the potential of enormous benefits to cost effectiveness and energy capture and storage efficiency on the industrial scale.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EA CH EN

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 253 | PS | 6054 |

**Title:** The Effect of Limb Darkening on the Sun During Solar Flares and Coronal Mass Ejections

**Student Name(s):** J. Puprriqi

**Abstract:**

The astronomical phenomenon of limb darkening is an optical effect seen in stars where the central part of the disc appears brighter than the edge. The limb darkening coefficient plays a crucial role in the surface temperature of the Sun, adding about 330.2 K to the regular temperature can be a catalyst for change. Limb-darkening could also present a possible change depending on the solar event, specifically solar eclipses. Lack of research on the effect of limb darkening on the Sun could hinder scientists' abilities to understand the Sun entirely. The purpose of this experiment is to understand limb darkening and solar events such as coronal mass ejections and solar flares in order to investigate whether the Sun changes at all during these solar events.

In order to better understand the effects of limb darkening on the Sun, image processing programs such as the LASCO/C2 instrument from the Solar and Heliospheric Observatory and online observatories will be used to make connections on limb darkening of the sun during solar events such as coronal mass ejections and solar flares. Due to the Sun's 11 year cycle which causes the regular limb darkening measurements to fluctuate, the mean limb darkening values will be taken from each season during one cycle to find any differences in the measurement. The method of data analysis used in this research project will be t-testing to compare the measurement of the limb darkening profile during solar flares and coronal mass ejections to when the Sun is quiescent.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 250 | PS | 6056 |

**Title:** Identifying the effects of radiofrequency-electromagnetic fields on small insects and locating high RF-EMF zones in the environment.

**Student Name(s):** A. Tsutsumi

**Abstract:**

Electromagnetic fields and radiation are becoming increasingly abundant and intense within the environment as dependencies on technologies like wireless routers and cell towers increase. The project focuses on the effects of fields on the neurological impacts on insects. The fields are measured using an EMF meter. Their effects on insects were analyzed through the measurement of neuron action potential. Field data was collected at points around Lordship, Connecticut to establish the baseline peak EMF strengths and radio radiation strengths respectively. Data of action potentials of insects exposed to different strengths of electromagnetic fields from 5 milligauss to 100 milligauss were collected. This data was recorded across multiple trials and a shift in data across differing EMF strengths was shown, but no correlation was shown between the strength and the number of spikes in the recorded time frame. Data on the Lordship area suggests that strong magnetic fields are not widespread and the strongest sources of EMF do not have much area. Based on these results, modern EMF emissions in residential areas are not a danger to insects and are not widespread. This implies more room to expand on the strength of electronics and wireless communication technologies in human environments, but more research should be done on the strength of electromagnetic fields in dense, more technologically populated cities with technology with 5G communications. Lordship does not have as much wireless technology as a large city may have so measurements of electromagnetic field and radio radiation strength may yield very different results.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AS EV

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 237 | PS | 6057 |

**Title:** Designing a Ground Collision Avoidance System to Inhibit Controlled Flight Into Terrain Accidents For Single Engine Aircraft

**Student Name(s):** M. Beaudette

**Abstract:**

Controlled flight into terrain (CFIT) is an accident in which an airworthy aircraft, under pilot control, is unintentionally flown into the ground, a mountain, or an obstacle. CFIT accidents were identified as a cause of 25% of USAF accidents. The main goal of this project is to design a ground collision avoidance system (GCAS) that will identify CFIT accidents before they occur. Many articles regarding CFIT and GCAS systems highlighted that these did not appear in small aircraft. The GCAS software was flashed onto an Arduino. To identify a CFIT accident is impending the code uses Airspeed (knots), altitude, and pitch. These values were supplied by the accelerometer, to determine airspeed, the barometer/GPS to determine altitude, and the gyroscope, to determine pitch. The data produced was fed into an algorithm that calculated the time before collision with the ground. If the time exceeded a threshold, the code sounded an alarm. In addition, the code used map data to determine the highest points. From that the code took a radius of highest points and compared it to the aircraft's altitude. If the code identified that the aircraft's altitude conflicted with a high point, the pilot was told to increase altitude. As proof of concept, the system was placed into an enclosure that can fit in a cockpit. The outcome is to provide a small, affordable system that will decrease CFIT accidents and can be retrofitted by pilots.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS EE AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 263 | PS | 6058 |

**Title:** Design of a Fe3O4/Bentonite/Graphite Coated Polyurethane Sponge for Economical and Eco-Friendly Oil Spill Recovery

**Student Name(s):** A. Kim

**Abstract:**

Annually, ~1.3 million gallons of crude oil spill into the ocean. Traditional oil cleanup methods are costly, non-efficient, and environmentally harmful, highlighting the need for simple and effective means for oil in water remediation. Both bentonite (an inexpensive clay) and magnetite (Fe3O4) have demonstrated oil-absorbing properties, with the latter remaining magnetic for facile retrieval of oil pollutants; however, neither has been applied in an effective way. In this research, bentonite, Fe3O4, and graphite were embedded into a polyurethane sponge, to create an oil-in-water remediation tool that removes both high levels (insoluble/visible) oil contamination in water, as well as soluble, undetectable contaminants. In use, the Fe3O4/Bentonite/Graphite-Coated Polyurethane (FBG) sponge is first placed atop a simulated, contaminated solution of floating, insoluble oil (with a gasoline model contaminant). After 10-minutes, the soaked FBG-sponge is removed and squeezed for ~100% oil recovery (via measure of oil's luminescence at 335nm (with a 235nm excitation). For a 4.8cm2 FBG-sponge, ~1.7g/L-cm2 of oil is removed from the water, and recovered for its original, intended use. In phase 2 of remediation, a second, new FBG-sponge is inserted into the now soluble oil-in-water resource. Within 4 days of floatation, 25.7 µg/cm2 oil is removed, and the water is free of oil or other contaminants from the sponge-remediation device. In phase-2, ~57% of the soluble hydrocarbons are recovered via a similar squeezing method. SEM analyses of the used FBG-sponges highlight their prolonged integrity and verify the presence of oil within its active ingredients.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EM EN AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 237 | PS | 6060 |

**Title:** Building a Machine to Test Whether Certain Face Masks are Protective or Not

**Student Name(s):** M. Barbagallo

**Abstract:**

In this project, my design goal was to build a machine that can test facemasks and determine how effective the mask is at blocking out particles. My design consisted of two main boxes, one "laser box" to house the laser components, and one "testing box" to house the mask and other testing components. These two boxes were connected via a flexible duct in order for the laser to pass from the "laser box" and into the "testing box." The "laser box" contained a 532nm, 5mW green laser that passed through a Plano-concave cylindrical lens in order to convert it from a beam into a vertical "sheet" of light. This "sheet" was then reflected through the flexible duct and into the "testing box." A mask was set up parallel to the "sheet" of light and a spray bottle was placed behind it. When the spray bottle was pressed and mist came out, any particles that passed through the mask would pass through the "sheet" of light and be recorded via the camera on the other side of the "testing box." The approximated number of particles to pass through each of the variety of masks ranged from an average of 0 to 150. I observed that the masks with some sort of filter appeared to be the most protective. These results proved that my machine was working and that masks with filters are more effective at blocking particles.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT EE

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 236 | PS | 6061 |

**Title:** Creating an Algorithm that Automatically Scores Tissue Images Like a Pathologist

**Student Name(s):** I. Yan

**Abstract:**

Cancer is the second leading cause of death globally. Detecting and treating cancer early on can save many lives. Pathologists have to look at tissue microarray (TMA) images manually to identify tumors, which can be time-consuming and inconsistent. Existing algorithms that automatically detect tumors have not achieved the accuracy of a pathologist so far, so they are not used widely.

A major challenge is that TMA images with different shapes, sizes, and locations can have the same score. Learning staining patterns in TMA images requires a huge number of images, which are severely limited due to privacy concerns and regulations. TMA images from different cancer types have common characteristics that could provide valuable information, but using them directly harms the accuracy.

For the first time, transfer learning was used to enlarge the training sample by extracting prior information from tissue images of different cancer types. The cancer TMA images were scored based on the severity of tumors. Images used in developing the algorithm were taken from the Stanford Tissue Microarray Database. The accuracy was calculated by comparing the score given by the algorithm to that of pathologists.

Transfer learning has made it possible for the algorithm to break the critical accuracy barrier. Pathologists had 75% accuracy, while the algorithm achieved 75.9% accuracy. This will allow pathologists to confidently use automatic algorithms to assist them in recognizing tumors consistently with a higher accuracy in real time.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT CS ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 258 | PS | 6062 |

**Title:** Meta Programming in JavaScript

**Student Name(s):** J. Colangelo

**Abstract:**

My goal was to research Meta-Programming and try to create Meta-Programs using Javascript. My research showed that a clean meta script, a program that generates code without outside influence, wasn't possible using Javascript. However, a non-isolated program allowed for creating a script that was similar to meta-programming in Javascript. This recreation is essentially a large JavaScript library. The first part of these functions are dedicated to If protocols and Array protocols, which run complex if statements, including nested if statements, in a single line. The Array Protocols provide for loops that can run through arrays and statements that can declare entire arrays. The second part of the Meta Library are the math-based functions and the OPER constructs. The math-based functions allow for simple or complex calculations, processing a maximum of four equations at a time. They include prewritten functions for common algorithms, such as background scrolling. The best part of the math-based functions is the OPER constructs. These constructs are rapidly processed algorithms that use O, P, E, and R as variables. OPER can perform thousands of operations with input. I wrote the OPER constructs to be used as parameters for the math-based functions, combining the processing power to exponentially increase the speed and capabilities of the program. While a true, clean Meta-Script was not possible, the Meta Library allowed for restructuring the syntax of a program on a massive level to write simpler code that could do more things, the closest possible Javascript recreation of clean Meta Programming.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS

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4. Is this project a continuation? ☐ Yes ☒ No
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# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 205 | PS | 6063 |

**Title:** Development of an autonomously navigating robot capable of conversing and scanning body temperature to help screen for COVID-19.

**Student Name(s):** R. Kim

**Abstract:**

Throughout the COVID-19 pandemic, the most common symptom displayed by patients has been a fever, leading to the use of temperature scanning as a preemptive measure to detect and isolate potential carriers of the virus. Human employees with handheld thermometers have been used to fulfill this task, however this puts them at risk as they cannot be physically distanced when taking forehead temperature readings and the sequential nature of this method leads to great inconveniences and inefficiency. The proposed solution is an autonomously navigating robot capable of conversing and scanning people's temperature to detect fevers and help screen for COVID-19. To satisfy this objective, the robot must be able to (1) navigate autonomously, (2) detect and track people, and (3) get individuals' temperature reading and converse with them if it exceeds 38ºC / 100.4ºF. An autonomously navigating mobile robot is used with a manipulator controlled using a face tracking algorithm, and an end effector consisting of a thermal camera, smartphone, and chatbot. The goal of this project is to develop a functioning solution that performs the above tasks. In addition, technical challenges encountered and their engineering solutions will be presented, and recommendations will be made for enhancements that could be incorporated when approaching commercialization.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE CS

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 242 | PS | 6064 |

**Title:** VISTA: An Smart IoT Device to Alert Clients Regarding Freezing Pipes, High Heating Bills, and Heat Sickness/Heatstroke.

**Student Name(s):** S. Srinivasan


**Abstract:**

My product, VISTA, is aimed at solving three critical problems: freezing pipes, high heating bills, and death due to heatstroke. The VISTA sensor system is built using Arduino and Adafruit technologies. The system provides a dashboard to configure the settings and sends mobile text alerts to users.

To address the freezing pipes situation, I researched and saw that a temperature reading of 55 degrees or above is preferable to avoid a pipe burst. Using this information, I decided to alert the user if the temperature dropped below that level; however, the users themselves can change this baseline temperature setting below which the user needs to be alerted.

To address heat exhaustion and heatstroke, I have to calculate the heat index value of the environment. Heat index is caused by a combination of the temperature and humidity. I used the Rothfusz regression formula to calculate the heat index value. The calculated value can be classified into 4 conditions (caution, extreme caution, danger, and extreme danger) based on the severity. I alert the user accordingly.

To target high heating bills, the system needed a way to detect air leaks. This led me to create a secondary sensor, identical in hardware, placed near windows, doors, and vents around the home. I also kept a primary sensor in the center of the house. Through my trials, I saw that a difference in 15 degrees was indicative of an air leak and thus alerted my user accordingly.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EV CS ET

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 258 | PS | 6065 |

**Title:** Examining the Relationship Between Labor Cost and Firm Strategy Through Mixed Methods Content Analysis on Panel Data and SEC Filings

**Student Name(s):** A. Kabra

**Abstract:**

With a desire for growth and longevity, corporations have looked to analyze labor cost, a proven indicator for capital success, to recognize which components of firms ensure maximal revenue. Interpreting such indicators help make vital managerial decisions regarding production cost adjustment and workforce investment. In recent years, it has been hypothesized that firm strategy also impacts corporate success but could not be evaluated due to the data's qualitative nature. In this study, I analyzed labor cost and its variability in relation to five prominent firm strategies through the creation of a novel mixed-methods methodology using tokenization and root-word identification. I examined a cross-sectional dataset spanning over 30 years with 3300 observations, performing content analyses on qualitative SEC 10-K filings and multivariate regression analyses for quantitatively extracted frequencies. Multivariable statistical models were analyzed via R and SPSS and organizational control variables, such as capital expenditure, were selected due to their high correlation with labor cost, acting as a way to avoid multicollinearity. Results showed that innovation, human resources, and consumer-focused strategies had a strong association with labor cost while growth, restructuring, and human resources shared strong correlations with labor cost variability ($p<0.01$). Such results led to conclusions on the implementation, advantages, and drawbacks of each strategy and their magnitude of significance in relation to capital success. Firms can use this novel mixed-methods approach to draw conclusions and make critical organizational decisions referring to cost allocation and strategy identification. Future studies should include content analysis using multi-layered analytical techniques and big data.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** MA CS AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 155 | PS | 6066 |

**Title:** Natural Function Restrictions, Identities, and Properties to Determine Finite Cardinalities of Solutions for Real-Valued Functions Projected onto Natural Space

**Student Name(s):** P. Chitirala

**Abstract:**

The aspects of the natural function nat(f(x)) and the natural solutions function nats(f(x)), which involves a compilation of definitions, properties, restrictions, identities, theorems, and relations are analyzed and developed for real-valued functions and determining the number of natural solutions (c_k, f(c_k)) of general functions such that the property c_k,f(c_k)∈N holds, where the x-values and the y-values of the points are both natural. These solutions are founded upon the equation ⌊f(x)⌋-f(x)=0 in which the natural solutions to this equation satisfy the natural solutions function, and thus the natural function, of f(x). The definition of the natural solutions function is formed in terms of the natural function, and the relations between the natural solutions functions of different real-valued functions are determined in terms of the mapping and organizations of the sets including unions, intersections, and morphisms.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** MA AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 255 | PS | 6069 |

**Title:** Comparing Algorithms to Solve the Exact Cover Problem with Sudoku

**Student Name(s):** A. Pourkavoos

**Abstract:**

The exact cover problem is an NP-complete problem in computer science with practical applications in coordinating schedules. This project compared the efficiency of C implementations of the backtracking algorithm to solve Sudoku, a special case of the exact cover problem. Each program stored not only the board but also a 9x9x9 array containing which digits were possible for each cell. This allowed the program to backtrack if a cell had zero possible digits remaining, or to immediately fill in cells with exactly one digit remaining. Three backtracking variations were compared. The first was the naive approach, storing only the above arrays. The second variation also stored how many digits remained possible for each cell, updating the count as necessary. The third variation stored, in addition to the above, a doubly linked list of all possible digits for each cell, implementing Knuth's Dancing Links algorithm. Each variation has faster asymptotic behavior than the previous but also requires more operations per individual action, such as eliminating a digit. Each variation was implemented in two ways: single-threaded and multi-threaded, the latter using the POSIX Threads (pthreads) library, for a total of six programs. Of the three variations, the naive approach was the slowest, and Dancing Links was the fastest. The multi-threaded programs ran approximately 20 times more slowly than their single-threaded counterparts (1.49 vs 33.1 ms per puzzle on average), likely because the overhead of creating and terminating threads outweighed the benefits of running an already-efficient program on four cores vs one.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS MA AT

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 262 | PS | 6070 |

**Title:** Design of a Wearable and Stretchable Hybrid Supercapacitor Biofuel Cell for Creation and storage of Energy via Sweat

**Student Name(s):** M. Minichetti

**Abstract:**

There is a growing and constant need for immediately accessible energy that is convenient, environmentally friendly, and sustainable. Wearable technology has gained much interest as a solution to provide convenient and portable energy, with the most recent developments suggesting their design as a biofuel cell (BFC) that is powered by the lactate-ion of human sweat. However, existing wearable BFCs have yet to provide maximum stretchability, energy production, and most importantly, energy storage for periods where the wearer is not perspiring. In this research, an elastic-wearable was constructed that contains an energy-efficient, lactate-powered BFC, as well as a supercapacitor (SC), addressing issues of energy storage. The new BFC was designed with stretchable ink drop-cast layers of SEBS, Ag, and COOH-CNTs. The SC architecture included stretchable SEBS, with a MnO2-CNT/COOH-CNT/PEDOT:PSS ink. The 4x6cm stretchable BFC was evaluated using 0-20mM lactate solutions, producing a linear voltage response up to 0.433V. Evaluation of the power density characteristics using 20mM lactate highlight maximum efficiency at 0.29V/21A, corresponding to ~6000µW, or 250 µW/cm2 for the device. While comparable to previous wearable BFCs, the new design possesses 15% more elasticity for the same output. The tandem SC was charged for 600sec with simulated 20mM BFC output, and the discharge measured at 50uA. SC discharge occurred over 1350sec from Einitial of 0.430V, which is 350sec longer than previous models, and ~57% more efficient along the discharge. During prolonged use, the BFC and SC electrodes were found to be durable, highlighting the device's efficacy for long-term use.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN EE BI

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 256 | PS | 6071 |

**Title:** Robotic Pancreatoduodenectomy (PD) vs. Open PD: A Meta-analysis-driven Algorithm to Enhance Surgical Decision Making

**Student Name(s):** E. Zhang

**Abstract:**

The Centers for Medicare & Medicaid Services estimates that health care expenditures will account for 19.7% of the GDP by 2028; therefore, medical resources must be prudently managed. Besides the $3000-6000 difference between robotic and open surgery, past studies have shown the inferiority of robotic pancreaticoduodenectomy (PD) as compared to open PD. However, given the rarity of operable pancreatic tumors, a study with an adequate sample size and a sufficient assessment of bias/heterogeneity remains unperformed. To accomplish this, a meta-analysis was conducted. The present study seeks to fulfill two objectives: (1) to determine if the efficacy and feasibility of robotic PD are comparable to those of open PD, and if so, (2) to provide surgeons and patients with a data-driven algorithm to facilitate the selection of optimal PD approach in a clinical setting.

Five databases were systematically searched for studies. Twenty-four studies totaling 12,579 patients were included in the final quantitative analysis. Six primary endpoints and four secondary endpoints were selected. The Mantel-Haenszel-Cochrane odds ratio and the Inverse Variance weighted average for categorical and continuous variables, respectively, were utilized. This meta-analysis concluded that robotic PD is at least comparable to its open counterpart: Five primary endpoints favored robotic PD and one favored open PD. The second conclusion comes in the form of an algorithm that offers insight into the favorable PD approach on a case-by-case basis. These findings will improve postoperative qualities of life for patients undergoing PDs and identify situations in which expensive robotic equipment is unnecessary.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** MA ME AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 232 | PS | 6072 |

**Title:** Exoskeleton Hand Based on MMG Signals for Partially Paralyzed Patients

**Student Name(s):** S. Lu

**Abstract:**

The hand is one of the most used parts in daily life; however, nerve damage, diabetes, and strokes can all cause partial paralysis to the hand. Current therapies include products such as the Hand of Hope, a robotic arm that aim for recovery through Nero-rehabilitation; it move the hand relying on electromyography (EMG) signals detect on the arm. This solution, however, requires a specific setting and cost immensely; even so, there are patients who don't recover. The aim of this project is for these patients to use their hands in daily lives through an exoskeleton which moves the hand through outside force. This paper propose a single layer Neural Network which output the action from an analysis of input Mechanomyogram (MMG) signals. Muscles emit a low frequency of vibrations when used, and transducers detect this frequency which is then referred to as MMG signals. Compared to EMG, it's easy to attach, and could be detected without direct skin contact, making it more convenient for at-home usage. On three of the main arm muscles, there will be six channels; different frequencies collected through these channels will then be segmented and overlapped. The Neural Network will then analyze the data and output the set action. Using this exoskeleton, patients with partial paralysis could use their hand in daily life, reducing the burden on their families and having a lives closer to normal.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN ME EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☒ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 197 | PS | 6073 |

**Title:** The Electrochemical Oxidation of Methane in a Fuel Cell Utilizing Carbon Sequestration

**Student Name(s):** S. Hillenmeyer

**Abstract:**

With carbon emissions of over 36 billion tons per year, the climate change crisis is expected to increase in severity over the coming decades. Methane, an extremely potent natural gas, is emitted into the atmosphere in larger quantities each year. While industries often flare this methane to oxidize it into carbon dioxide (a much less potent gas), these emissions are still harmful to the environment. To ameliorate this issue, this project aims to devise a fuel cell that will convert oxidized methane (CO2) into non-polluting carbon products such as baking soda (NaHCO3). Simulations were run using COMSOL v5.5 (modeling software) to determine optimal conditions. The optimal inlet pressure and NaCl inlet concentrations that reduced the overall emission of CO2 and maintained charge neutrality in the fuel cell were found to be 7000 Pa and 2 mol/m3, respectively. These important conditions identified herein can be used by future scientists to optimize a carbon sequestration fuel cell that will eliminate carbon emissions and generate additional power from the methane oxidation process. This fuel cell will become widely implemented throughout the world. This will in turn significantly mitigate climate change, a pressing issue that our world currently faces.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ET CH EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☒ Yes ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 235 | PS | 6074 |

**Title:** Using Binary Star Systems to Detect Unseen Matter.

**Student Name(s):** B. Holmes

**Abstract:**

Nearly four-fifths of all observable light comes from two stars which orbit each other in a pair. These binary star systems are not only important to understanding the observable universe, but how life on Earth functions. Calculating the masses of these stars is essential to gain not only the size of these systems, but how they differentiate. Differences are key factors such as Parallax, a displacement or difference in the apparent position of an object viewed along two different lines of sight, and is measured by the angle or semi-angle of inclination between those two lines. Parallax coincides with Parallax error, which could be mechanical, or, which could be the result of outside matter. The SIMBAD, Gaia, and Sixth Orbit Catalogs are all essential to research, using these databases information such as the period of time the stars take to orbit, the star name, semi-major axis of rotation, and finally, using equations to find the mass sum and the difference of the masses, the mass of the binary star system. Using the SIMBAD and Gaia databases, different Parallax errors were discovered in binary star systems of the same, or nearly identical masses. This would hint at not only a chance of mechanical error, but an outside force acting as an influence on this measurement. True data collection is planned to begin within the following weeks, around the date of March 20, 2021.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 255 | PS | 6075 |

**Title:** Wildlife Recognition from Camera Trap Data using Computer Vision Algorithms

**Student Name(s):** Y. Dai

**Abstract:**

Camera trap is a common method to capture wild animals on film. It has been widely used in wildlife conservation for decades. With increasingly available vision data from camera traps, it becomes prohibitively costly to manually extract useful information from these data. Leveraging recent advances in machine learning, I adopted and fine-tuned a popular convolutional neural network (CNN) architecture called YOLOv3 to automate knowledge extraction from the camera trap data. Specifically, I trained the YOLOv3 model on Zooniverse's public large-scale camera trap dataset, which contains wildlife species information but lacks the bounding box information. In order to help the model highlight animals in the images, I manually labeled thousands of camera trap photos of wildlife like rhinos, lions, and impalas using a visual object tagging tool to prepare for the supervised learning. As a result, the deep learning model fine-tuned on these labeled training data are able to detect and recognize more wildlife species with high accuracy and confidence value compared to the pre-trained model. Meanwhile, compared to the existing work by Norouzzadeh et al. (2018) and Willi et al. (2019), my model further provides bounding boxes with predicted labels that can facilitate the wildlife identification and recognition. In this way, we can further reduce the human effort for scientists and zoologists to analyze camera trap data and possibly improve the intelligent understanding about wildlife at lower costs. Further work of this project may include real-time wildlife detection in camera trap videos and the design of websites or mobile apps.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EV CS EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 254 | PS | 6076 |

**Title:** Developing Tetherless Motion Tracking of Wandering Insects with an Omni-directional Servosphere Robot

**Student Name(s):** N. Lee

**Abstract:**

This project is the development of a servosphere robot capable of treadmill-style operation and tetherless motion tracking. Wandering insects are model organisms for researching motion patterns and how they are affected by certain genetic factors. However, conventional methods of motion tracking, such as tethers or markers, interfere with insects' natural behavior, yielding inaccurate results. An omni-directional sphere, or servosphere, can rotate in any direction around any axis, such as with "Hamster ball" robots. A servosphere could be used as a treadmill for an insect, counteracting and recording its movements.

The procedure follows three sections: designing and constructing a servosphere robot using servo-powered omni-wheels, deriving theoretical methods of servosphere operation, i.e., an inverse-Jacobian transformation matrix, and implementing operation into the robot using Python-based motion tracking and computer vision.

The servosphere robot was evaluated based on two criteria: consistency of operation as a treadmill, and pathing error. Consistency is the frequency of successfully moving the silhouette from an arbitrary position to the sphere's center, and pathing error is the divergence of the silhouette's motion from the ideal path, measured as the trajectory's standard deviation. The results were promising, with 100% consistency and an average error of 0.484cm across all angular positions.

In this project, a servosphere robot was successfully constructed and operated by implementing theoretical models, and the viability of the servosphere robot as a motion tracking system was demonstrated. It can be used in research with genetically edited insects to isolate the effects certain genes have on motion behavior.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE MA CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 244 | PS | 6077 |

**Title:** Using SiO2 Spray to Reduce Microplastics Dissolved Into the Oceans

**Student Name(s):** L. Southam

**Abstract:**

The purpose of my project was to assess whether SiO2 in a liquid spray form could be used to prevent the spread of Microplastics. SiO2 is an ultrahydrophobic substance, meaning it could theoretically slow the dissolution process on an object coated with it. Microplastics come in two forms: Primary and Secondary, each one can disrupt the food chain and ultimately harm humans. Primary microplastics are specially designed to come in small sizes, they are mostly used in toothpaste and cosmetic products. Secondary Microplastics are a much bigger problem, these are the dissolved remnants of larger plastic products and are much more common. To try and combat this more widespread contamination I tested the efficiency of SiO2 spray on water bottles. Plastic water bottles are one of the most common pollutants with 481.6 billion being used in 2018 alone. My aim was to create a layer of coating that might slow down the dissolution process, slowling the spread of Micro plastics. My experiment was conducted by coating three water bottles in SiO2 and placing each one in a sealed glass container, with one water bottle being set without any spray as a control. Each week for 5 weeks I measured the ppm, to indicate the number of micro plastics added to the water. This was aimed to pave the way for more research in perfecting the spray itself. I plan to refine this idea and use it as a long term solution to microplastic pollution.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EV EN ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 231 | PS | 6078 |

**Title:** Development of a Novel Classification Model to Determine Vegetation Habitability of Exoplanet Atmospheres Via Random Forest Machine Learning Algorithms.

**Student Name(s):** J. Gottlieb

**Abstract:**

Based on a 2013 NASA report there are ~11 billion potential exoplanets present in the Milky Way Galaxy of these, ~4,000 exoplanets have been confirmed. To further evaluate exoplanet candidates, data must first be filtered and sorted. Machine learning algorithms can streamline this processing time by providing definitive insight into which exoplanets require prioritization for further investigation. A novel application of a random forest algorithm was used for the analysis of exoplanet transit spectroscopy to determine the habitability for a given exoplanet's atmosphere. The data set used consisted of 20,206 transit spectroscopy points, 3,143 were collected from the Nasa Exoplanet Archive; the remaining 17,063 points were generated using Nasa's Planetary Spectrum Generator. Performance analytics data provided the model with Precision, Recall, Accuracy, and F-1 Scores for 0 and 1 Habitability rating as 0.68, 0.97, 0.82, 0.93, 0.74, and 0.95 respectively with an accuracy of 0.91. The model's ability to predict Habitability values of 1 with performance scores all above 0.9 indicates that the model is successful. Limited bias in the model's predictive capacity of inhospitable values was detected, as indicated by sub 0.9 scores. Through larger data set value input, it is expected that this bias will be eliminated. This novel machine learning model can be used to increase the efficiency at which exoplanet data is analyzed and interpreted, assisting in the prioritization of celestial bodies which merit further investigation.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS PH AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 244 | PS | 6079 |

**Title:** Sentiment Analysis on Twitter Data Regarding the 2020-21 Georgia Senate Runoff Election

**Student Name(s):** S. Jonnalagadda

**Abstract:**

In the age of social media, opinions can be shared easily and quickly. There are many platforms on which users can post highly biased and political messages, most of which display a positive or negative attitude towards a candidate. Twitter is a goldmine for such messages, and its API (Application Programming Interface) and the Tweepy library allow users to extract the messages. To get access to the API, I had to create and obtain approval for a Twitter developer account. Then, I had to make an app in the API in order to receive a set of keys, which must be concealed for account security. With those keys and the Tweepy library, the tweets can be extracted and saved as text in a pandas dataframe alongside the timestamp of the tweet. This text has to be pre-processed, meaning that words that are neutral will be removed and added to the dataframe. Raw tweets containing redundant information are disorganized. Pre-processing will help overcome those issues. After pre-processing, the tweets can be analyzed for sentiment by using the TextBlob library and saving the polarity in the dataframe. With the polarity saved, the data can be averaged. When 50% of the votes were counted, Perdue's average polarity was 0.113, and Ossoff's average polarity was 0.135. After 90% of the votes had been counted, Perdue's average was 0.092 and Ossoff's average was 0.197. My code predicted that Ossoff would win because of his higher average.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 234 | PS | 6080 |

**Title:** Artificial Turf VS Grass Fields

**Student Name(s):** J. Peralta

**Abstract:**

There are many debates over which type of field is the better choice to be used for sports. There are many factors that have to be accounted for such as costs, benefits, disadvantages, etc, of each field. However, one of the main things that have to be considered is an athlete's overall performance on the field. The goal of my project is to determine which field is better economically and performance wise. I conducted an experiment with 3 students on both artificial turf and grass fields. The first fitness test was ladders. Each student had to run while putting 2 feet in through each ladder and then run to a cone 8.3 feet away from the ladder and then back. The mean of the time (seconds) of all the students on the grass field was 18.3. On the other hand on the artificial turf field the mean of all the students times in seconds was 16.98. For the next test it was shuttles. For this the students had to run to a cone located 8.3 feet away, back to the original cone, a cone placed 16.6 feet away, and then back again. The mean time on the grass field was 14.1 seconds. On the other hand the mean time for the artificial turf field was 13.7. These results clearly show that although the improvements were not drastic, artificial turf fields improve an athlete's performance.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN PS ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☐ Yes ☒ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 253 | PS | 6082 |

**Title:** Comparison of Chemical Exposure from Face Mask Materials Before and After Washing Treatments

**Student Name(s):** A. Su


**Abstract:**

Face masks slow the spread of COVID-19, but some materials may be unsafe due to chemical exposure from hazardous particles, including dyes, polycyclicaromatic hydrocarbons (PAHs), and phthalates. The purpose was to determine the exposure of sixteen toxic chemicals in mask materials and the effect of washing treatments on exposure from fabrics. It was hypothesized that exposure would differ between materials–with the highest exposure in unwashed denim–and decrease with increased washes because indigo dye can leach out of denim, and washing would likely reduce the number of particles that could be breathed in. Fourteen materials were placed in separate airtight glass containers with a polydimethylsiloxane sorbent bar to absorb chemicals for 24 hours. The fabrics were then washed thrice with cold water at 21.0ºC in a portable washing machine, dried, and placed in containers. The polyesters were washed, dried, and placed in containers three more times. This process was repeated with hot water at 55.0ºC. The unwashed N95 mask resulted in the highest total exposure. Of all materials and washing treatments, unwashed red polyester was highest in PAHs, while N95 and surgical masks were highest in phthalates. Trends show decreased exposure after the third wash and increased exposure after the sixth wash for both hot and cold treatments. The hypotheses were partially supported since exposures differed between materials and decreased after three washes. These results can be used to improve current mask and washing treatment recommendations by accounting for chemical exposure from mask materials in addition to protection against COVID-19.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ME CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 158 | PS | 6083 |

**Title:** Comparing the Efficiency of Autonomous and Regular Vehicles With New Requests

**Student Name(s):** D. Luo

**Abstract:**

Autonomous vehicles will become prevalent among the public within a few years, aiding in the reduction of traffic through communication between vehicles. However, properly planning the routes of these vehicles and testing their efficiency has been recently subjected to research. This experiment compares the efficiency of autonomous and regular vehicles with the appearance of new requests with total time traveled as the measure. Using Python, a computer model records the total time a regular and autonomous vehicle needs to pick up every location and fulfill new requests. The autonomous vehicle can change its route with the appearance of the new requests while the regular vehicle must make a second trip. An 8x8 grid is used for simplicity. This experiment comparing the efficiency of autonomous cars and exploring the potential of rerouting can inspire scientists to pursue the development of a smarter car. The results will help the public understand the potential increase in the efficiency of autonomous vehicles.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT MA CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 143 | PS | 6084 |

**Title:** pH Levels On Different Types Of Beverages

**Student Name(s):** N. Valencia


**Abstract:**

Beverage sizes have been increasing since the year 1955 and with those, they contain lots of surgery components in the drink. If the drink is too acidic it can cause dental problems and lead up to health problems as well. The purpose of this experiment is to test if sugar affects the acidity or alkalinity of a beverage. To determine how acidic and how basic a beverage is; it is best to use a pH indicator strip. Each beverage was put in different cups and labeled with a black sharpie which type of beverage it contained. The results of the experiment show that the most acidic beverage was soda (Ginger ale) with a pH of 2 and Snapple (pH 2). Both beverages contain between 32 to 24 grams of sugar. The most basic beverage was Ginger Root tea with a pH of 7.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CH CH CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 253 | PS | 6085 |

**Title:** Hazel, an automated mood enhancer, alarm clock, and safety monitor.

**Student Name(s):** J. Park

**Abstract:**

Hazel was created for people who live solitary lives to combat Kodokushi, fatal accidents that happen when no one is around to help, while helping to maintain their mental health. This is done by creating a safety monitor that automatically detects the user's presence and collects data of their current mood that is not only used to analyze their mental health but also to improve their mood by diffusing the most adequate aroma.

Designed as a diffuser, Hazel holds five water tanks for each aroma. After researching the unique functions of aromas, five were chosen from the most relaxing Lavender, Rosemary, Lemon, Basil, to the most refreshing Peppermint. To create a user-friendly UI, tag-based tarot cards were added, designed to visualize complex emotions. Whenever a card is tagged, Hazel automatically gathers other mood-influential data such as discomfort index and weather. Hazel then calculates them to diffuse the corresponding aroma indicated with a specific LED color when the user is detected with an IR distance sensor. The sensor is also used as a safety monitor, which, if not found in 72 hours or if a drastic mood swing is detected, sends an alert with the user's name, age, and location to the registered email. To improve user's sleep patterns, an alarm system is set by the LCD clock with a day and night alarm each diffusing peppermint and lavender with the sounds of nature. Hazel will need more development to become more personalized by better analyzing mental patterns of the user.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE ME BE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 254 | PS | 6086 |

**Title:** Generalized Correction of Spatially and X-Z Correlated Errors through Adaptive Minimum-Weight Perfect Matching Topological Algorithms

**Student Name(s):** S. Florin

**Abstract:**

Topological quantum error correction uses the topology of surfaces like the plane or torus to correct quantum errors, helping quantum computing to be successful. However, topological quantum error correction assumes that errors occur independently, whereas real errors are often correlated. This project considers both spatial and X-Z correlation. The error model uses fixed-length random walks of errors, providing the spatial correlation. Also, chains are made up entirely of either Pauli X, Y, or Z errors, each with independent fixed probabilities. This forces the decoder to consider X-Z correlation. The decoder is a variation of the minimum-weight perfect matching (MWPM) algorithm. Instead of the weight of an edge being the taxicab distance, it is defined using a combination of functions on distance and chain syndrome overlap. The distance function combines models of the fixed length of the walk and partitions of the walk into staircase-shaped chains. The overlap function peaks at zero and complete overlap to account for Y chains. The structural changes to the algorithm reduce errors by >90% when compared to the error model and algorithm from the initial research. The new decoder accounts for a variety of parameters so that errors are more realistic, including error type distribution and the probability that the type of walk aligns with syndromes. Independent of these parameters, this revised algorithm provides at least a 30% reduction in errors as compared to the traditional MWPM algorithm. This shows this algorithm can successfully adapt to these random walk errors and improve quantum computations.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS PH MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 249 | PS | 6087 |

**Title:** The Hat and the Mouse: A Practical Hands-Free Method to Control a Personal Computer

**Student Name(s):** P. Noe

**Abstract:**

Due to their unique challenges, many quadriplegics experience difficulties when performing everyday tasks, like using the computer. This head mouse was designed to allow users access to full functionality of a PC mouse without needing to use their hands. The device was programmed using the C++ programming language, and it utilized various Arduinos as well as Bluetooth and voice control features. In order to determine the performance and functionality of the headmouse, experiments were conducted to measure battery life, voice control reliability and the degree of head tilt required to move the cursor across the computer screen. The voice control module was found to be 94% reliable, and the required degree of head tilt for full screen deflection was around 10°. Although the battery life was only 42 minutes, the device's overall performance was still very good. In being able to provide users with complete control of a computer mouse while still presenting minimal errors, the headmouse demonstrated its ability to carry out the functions for which it was designed. In the future, other features could be added to the device, including the recognition and implementation of key words and phrases, such as "today's news," which could be carried out using the Arduino keyboard.h library. Additionally, the device's power source could be changed to a 6 volt battery, as opposed to a 9 volt battery, to minimize the risk of overheating and lessen the weight of the headmouse. Use of Bluetooth Low Energy (BLE) could also extend battery life.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT CS EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 210 | PS | 6088 |

**Title:** Utilizing Electromagnetic Pulse Generation to Disrupt the Electron Transport Chain as a Novel Technique to disrupt Harmful Algal Blooms

**Student Name(s):** S. Volcy

**Abstract:**

This project was developed with the proposition that It was possible to study the effects of continued electromagnetic pulses on the lifespan on algae. This proposal is a novel method to mitigate harmful algal blooms in the ocean. Currently there are limited protocols to mitigate harmful algal blooms once they spawn in the ocean, leading to potential hypoxic conditions to the surrounding ecosystems. Electromagnetic pulses were deemed as the topic of interest to mitigate these blooms where a electromagnetic field works to overflow the algae's electron transport chains resulting in a higher energy exertion to purge the electrons then can be produced, effectively killing the plant after prolonged exposure. After extrapolating this research from different sources, experimentation began by outfitting a 10-gallon tank where the model organism Spirulina major were given 4 weeks to grow undisturbed, minimal agitations to the tank were the reintroduction of water, to offset evaporative water loss, and stirring to reduce Spirulina clumping together. After 4 weeks, a self-constructed electromagnetic pulse generator was introduced into the tank. This experimentation can greatly help oceanic communities and ecosystems by stopping too many toxins that harmful algal blooms excrete from getting ingrained into the environment and inhibiting plant, marine, and human life from interacting with that area.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE EM PS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 248 | PS | 6089 |

**Title:** Influence of magnetic field on the viscosity of fluids doped with conducting and non-conducting particulates

**Student Name(s):** S. Gu


**Abstract:**

This project explores the influence of static magnetic fields on the viscosity of distilled water doped with conducting and non-conducting particles (paramagnetic ions from KCl, NaCl, and MgCl2, and free radicals from starch, whose magnetic susceptibility would increase under the presence of static magnetic fields (J. Wronka, 1948)). Using a vertical falling ball viscometer, the time of descent through sections of the fluid in a tube is measured. A change in the time indicates a change in fluid drag and therefore, viscosity. A transverse magnetic field is applied to the fluid using permanent magnets with maximum field intensity up to 80mT. A qualitative increment in viscosity by the application of fields is demonstrated by the data, evidenced by the changes in descent time. Contradictory results were suggested by some behaviors observed, as in more trials the wake of the ball's path becomes turbulent under the influence of the magnetic field, indicating a decrease in fluid viscosity because the more frequent turbulence indicates a higher Reynolds number and a smaller viscosity. The mechanism for starch solution to increase its viscosity is likely that the free radicals line up with the magnetic field lines, producing molecular chains similar to the ferromagnetic particle chains formed in the magnetorheological fluids. The mechanism for the ionic solutions' increase in viscosity cannot be explained by this project, but a paper by J. Lielmezs, H. Aleman et al. suggests that it could be the spin-exchange mechanism related to the proton transverse relaxation time.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 223 | PS | 6090 |

**Title:** SpaceX; Friend or Foe?

**Student Name(s):** G. Gogliettino


**Abstract:**

Space X's new operation, Starlink, has been approved to launch 12,000 satellites into low earth orbit, with plans of an additional 30,000. With unprecedented numbers like this, the concern of the Kessler Syndrome, the event in which the collision of space junk or debris creates additional debris, and inevitably a chain reaction of collisions, arises. The Starlink satellites have a current failure rate of 2.5%, which reinforces this concern. If the corporation continues to expand this operation, then the satellite failure rate would create enough space junk to increase the probability of the Kessler Syndrome. This experiment used the quantities of satellite launches in the past years and extrapolated them to predict the numbers in future years to come. This was done twice, once excluding the Starlink operation in the prediction and another included it. It was implied that the operation would be conducted on the proposed scale of 42,000 total satellites. The satellite failure rate was applied to the results to quantify the failure rate's impact. This indicated that 1050 inactive satellites would be amassed by the time the Starlink operation concluded. This figure is 10% of the current number of inactive satellites in orbit. Although the probability of the Kessler Syndrome cannot be quantified, the significant increase in inactive satellites would rationally make an event like the Kessler Syndrome more probable.


**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 247 | PS | 6091 |

**Title:** Comparison of Machine Learning Models for Short-Term Forecasting of Solar Power Generation Output: A Case Study

**Student Name(s):** D. Yuan

**Abstract:**

The Loomis Chaffee School's solar field is the largest solar power plant among any K-12 school in Connecticut, built in late 2019. Like all solar fields, its power generation is highly variable and dependent on external factors such as weather. For such photovoltaic power sources, reliable and successful integration into the larger power grid system depends upon knowledge and prediction of future power output. The application of machine learning models for solar power output forecasting has thus become popular in research and literature, replacing past approaches based on statistical or physical models. This project aims to determine the feasibility and performance of applying three machine learning algorithms, support vector machines; random forests; and k-nearest neighbors, for short term solar power output forecasting, through leveraging the rich data generated by Loomis' solar array in the first comprehensive study of that data. After a preliminary data exploration phase, data is preprocessed for elimination of error values and normalization. Hyperparameter tuning is conducted to improve model performance. Only in situ data is used, and findings indicate that the training of the three models on the limited set of data features has promising utility in power prediction, with a significant improvement over a baseline persistence method for hourly prediction and best performance by support vector machines. In the future, efforts to extend this research include adding local weather data and establishing a data monitoring platform for the student body at Loomis Chaffee for education and promotion of solar energy.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS ET

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 249 | PS | 6092 |

**Title:** The Core of Neptune: Discovery of the First Sub-Neptune Planet with a Stripped Envelope

**Student Name(s):** D. Zhou

**Abstract:**

An exciting discovery in exoplanet demographics has revealed an astonishing number of planets within the 1.0–3.9 Earth radii (R ⊕) range. These "intermediary" planets fall within two groups: smaller-radius (~1.3R ⊕ ) planets, called super-Earths, and larger-radius planets (~2.4 R ⊕) , called sub-Neptunes. Surprisingly, few exoplanets of ~2R ⊕ were detected between these two groups. It is hypothesized that planets with ~2R⊕ are enveloped in fine gaseous envelopes that dissipate or accumulate, leading to two distinct groups of exoplanets. By analyzing K2 lightcurve data and Dharma Planet Survey radial velocity data using both the transit method and radial velocity (RV) method, this study discovered exoplanet HD 73344b, the first sub-Neptune planet with a stripped envelope. My research independently confirmed the existence of the exoplanet HD 73344b and determined the stellar rotational period to be 8.8 days using an auto-correlation method and a periodogram. The properties of HD 73344b were further analyzed to provide insight into its atmosphere and composition. My findings indicate that HD 73344b has a mass of 28 M ⊕ and a radius of 2.6 R ⊕, suggesting that the exoplanet has an H2O-abundant surface and a dense metal-heavy core of iron and nickel. The exoplanet's composition and density support the hypothesis regarding the lack of exoplanets with ~2R ⊕. My research could aid our understanding of planet formation and contribute to the search for habitable planets. Using James Webb Space Telescope (JWST) further research could be done to detect its atmospheric molecules of HD 73344b.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH EA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 248 | PS | 6093 |

**Title:** Python Security Functions

**Student Name(s):** S. Vakacherla

**Abstract:**

The purpose of this project is to see if a program written using Python can be simple enough for anyone with or without CS knowledge to use and also be effective in protecting against hackers. As the world continues to move online, cybersecurity becomes a more pressing issue. In this project, the program had different cybersecurity functions: a password checker that would say whether a password was weak or strong, a password generator that would output a sample strong password using random character generating, a URL decoder that would decode a percent-encoded URL, a base64 function that would be able to decode base64 and encrypt messages to base64, a timestamp function that would output the immediate time and date down to the second, and an API function that would - given an IP address - output where this address is based, what corporation it is associated with, and how many different security firms have flagged it as harmful. These different programs were created using the programming language Python and then tested on the IDE Pycharm. The results of the project were excellent - the program worked better than expected, and the user interface was easy to follow. Each program worked as intended, and the API program also was able to find other information such as how many other IP addresses are associated with the given one. In conclusion, this project proved that a python program could very well be effective against hackers, and easy to use at the same time.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 251 | PS | 6095 |

**Title:** A Novel Method of Identifying Redox and Non-Redox Chemical Reactions

**Student Name(s):** V. Zhu

**Abstract:**

Oxidation-reduction (Redox) reactions are a type of chemical reaction involving a change in the oxidation states of atoms. The traditional way of identifying whether a reaction is redox or non-redox involves determining the oxidation states of each atom of the reactants and products, and comparing them. This project aims at studying a new method of identifying whether a reaction is redox or non-redox based on the number of elements and compounds in a chemical reaction.

Every inorganic chemical reaction that could be found (over 1000 reactions) was used in the research. It was shown that there is a correlation between the number of compounds and elements, and whether or not the reaction is redox. It was determined that if a chemical reaction has a larger number of compounds than elements, then the reaction is redox. If a chemical reaction has a larger number of elements than compounds, then the reaction is non-redox. If a chemical reaction has an equal number of compounds and elements, then the reaction could be either redox or non-redox. For example, in the decomposition of water, there are 3 compounds (water, hydrogen gas, and oxygen gas), and 2 elements (hydrogen and oxygen). Therefore, it can be determined that the reaction is redox.

In summary, it has been demonstrated that a reaction can be classified as redox or non-redox by comparing the number of elements and compounds in a given chemical reaction. The mechanisms responsible for this observed relationship warrant further investigation.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 240 | PS | 6096 |

**Title:** Using Solar Simulation to Quantify Photochemical Degradation Rate of Microplastics

**Student Name(s):** H. MacDonald

**Abstract:**

Microplastics are plastic fragments less than five millimeters in diameter that are sourced from both primary and secondary sources, either intentionally produced for industrial use, or created by fragmentation of larger plastic materials. Both types of microplastics densely populate Earth's oceans and have shown to be harmful to marine life and humans alike. This study examines the differences in the photodegradation of each type of microplastic, and identifies those that photodegrade most effectively. Six types of microplastic fragments were each suspended in distilled water and exposed to solar simulating UVA and UVB bulbs for seven days to replicate the effects of natural sunlight on microplastic fragments at sea. The fragments were then filtered using one micrometer filtration and measured by mass differences to determine the amount of plastic decomposed per week. The increase in vapor pressure of the container was measured at the beginning and end of each cycle to determine possible volatile products of the decomposition. This study is intended to quantify the rate of photodegradation between these microplastics, and explore the chemical decomposition of each plastic. Findings show a rate of degradation in branched polymers over 30% higher than that of linear polymers, with polystyrene showing the most rapid degradation of 42.7 milligrams per day of UV exposure. This research, and further studies, can aid in understanding which plastics are best to produce and consume in order to minimize their effect on water systems and coastal environments globally.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EM EV CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 170 | PST | 6501 |

**Title:** Recirculating Shower Filtration System: Utilizing Natural, Cost-Efficient, and Effective Materials to Consolidate The Purification of Water

**Student Name(s):** M. Spiess, N. Altman

**Abstract:**

The objective of this project was to make a recirculating water shower system that creates potable water using natural resources, nor the requirement of additional electricity. Due to the use of natural materials, maintenance of the shower will be dramatically reduced. Our shower system filters the used water and integrates it back into the pipes of the shower, to be used again by the next person. The filter removes dirt, bacteria, debris, and biodegradable shampoo. It does so with different filtration methods in each part of the filter. As the water moves from top to bottom, the stages remove the largest to the smallest impurities from the water to ultimately leave it potable. The system purifies the water to below 5 Nephelometric Turbidity Units (NTU), the recommendation for drinking water by the World Health Organization. Cleaned water is collected and sent back to the shower head by a solar paneled water pump. Our economical shower system has the potential to reduce disease and allow for increased hygiene without wasting water.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT EN EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 159 | PST | 6502 |

**Title:** The Drinker Dehumidifier

**Student Name(s):** R. Mistry, A. Dunning

**Abstract:**

This engineering design challenge was to create a water collection device that will collect a substantial amount of clean water for drinking purposes. This mockup is meant for areas that face water scarcity such as the Middle East and North Africa. To build our device we used a large plastic container and set it up with a closed system inside. To create our closed system, we used a copper coil that was sealed on one side and had a metered valve on the other side. This metered valve can be connected to many different cooling products that the user may use. The idea behind the product is that humid air will form condensation onto the cold copper coils and that newly formed condensation will drip down the coil into one of the two drip pans. Our mockup has many parts that will function on a prototype however we do expect a working prototype of our mockup to work efficiently.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 235 | PST | 6503 |

**Title:** Sucrose vs Drosophila melanogaster

**Student Name(s):** J. Reels, C. Howard

**Abstract:**

Drosophila Melanogaster can be used as research models that help us make many significant discoveries that can be applied to the learning of human physiology. In our experiment, we are using flies as models in place of people. The purpose of this experiment is to show the effects of Drosophila Melanogaster when exposed to a high sugar diet that will potentially cause diabetes. This idea came to us because of the potential future advancements, further insight into high concentrated sugar diets that can show how humans could potentially be affected, prevention, etc. The experiment will be set up in the following manner, flies will be separated into three groups, group one having the normal fly food recipe, group two will have a 15% increase of dextrose, and group three will have a 30% increase of dextrose. We will measure the number of deceased flies, and determine whether they died from their insulin receptors being ruined (resulting in diabetes). This experiment will follow death rates because when exposed to a diet high in dextrose we hypothesized we'd see changes in death rates, this is because the flies won't be able to metabolize all of the sugar they consume which will cause their insulin receptors to malfunction and many of them will die off. This experiment will show how diabetes in Drosophila Melanogaster affects their day-to-day actions, while also demonstrating the fluctuations in death rates.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AS BE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 121 | PST | 6504 |

**Title:** Creation of a Malleable Hydrogel Bandage for Long Term Wound Treatment

**Student Name(s):** F. Brown, C. Boateng

**Abstract:**

The objective of this project was to create a malleable adhesive hydrogel bandage that provides both a higher quality and more natural healing environment, potentially having the capability to deliver medicine and monitor the wound. The result would be reduced infection because of the dramatic decrease in interaction with the wound, thus limiting the exposure of the injury to harmful bacteria. The malleable hydrogel, synthesized through the crosslinking of ionic bonds joined in a very delicate concentration of polyacrylamide to alginate, allows for this optimal environment to be created. Using the gathered data, an optimal concentration was determined by altering different ratios of these polymers and acids, ultimately resulting in a hydrogel bandage that is more effective to the healing process.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EN ME AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 159 | PST | 6505 |

**Title:** Stock Simulator

**Student Name(s):** A. Patel, M. Gallo, E. Lombardo

**Abstract:**

The objective of our project is to allow people to practice investing in the stock market, and become more aware of the methods by which they can earn money.

To do this, we created a simulation of a stock market, using ProcessingJS, a JavaScript library, in which people can practice investing money and see the results of their investments.

The simulator includes 8 randomly generated stocks, which are unrelated to real world stocks. They have random price values, which randomly fluctuate similar to how real stock prices work.

Users are given $1M in starting currency, and can buy and sell any number of shares of any stock whenever they please with the currency they can afford to spend. The simulator keeps track of the earnings produced by each owned investment, as well as the earnings owned overall (in $ as well as %).

The simulator successfully models a real-world stock market and allows users to practice before spending real money.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 236 | PST | 6506 |

**Title:** Determining the Trend of Nitrogen Deposition Near Lake Erie from 2002-2012 Due to Its Influence on Lake Eutrophication

**Student Name(s):** C. Chen, C. Chen

**Abstract:**

Eutrophication, the excessive richness of nutrients in a body of water, can trigger the growth of harmful algal blooms, which often affect Lake Erie. They consume valuable resources and release toxic chemicals. Nitrogen and phosphorus from agricultural applications are known to contribute to eutrophication, however, the role of atmospheric nitrogen is unknown. The purpose of this project was to assess atmospheric nitrogen deposition levels near Lake Erie from 2002 to 2012. The independent variable was time, and the dependent variable was nitrogen deposition levels. It was hypothesized that depositions of NO3 would decrease while NH4 depositions would remain stable. Plots for yearly and seasonal NH4 and NO3 deposition data were graphed and quantitatively analyzed using linear regression. Nitrogen deposition trends were qualitatively compared to modeled data from the CMAQ System, which provides predictions of air quality variables. NO3 annual deposition trends decreased, and NH4 annual deposition trends remained almost flat. For the seasonal graphs, NO3 deposition trends decreased, and NH4 deposition trends remained almost flat. It was concluded that depositions for NO3 decreased and depositions for NH4 remained fairly stable. CMAQ tended to undershoot deposition predictions, especially for oxidized nitrogen. A machine learning model that uses CMAQ outputs for eutrophication prediction is under development, but one uncertainty is the role of atmospheric nitrogen deposition. The findings of this study will help improve this model and create methods to prevent eutrophication, protecting freshwater systems and coastal waters.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EV

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 255 | PST | 6507 |

**Title:** Exploring the possibility of artificial gravity for space flight.

**Student Name(s):** J. Shanks, W. Cashman

**Abstract:**

The purpose of this experiment is to show possible solutions to the adverse effects of low gravity on the human anatomy during long-term space flight. The solution we propose is the use of a 1g rocket and the effectiveness of this form of artificial gravity. In our experiment, we constructed two identical 3D printed baskets. In one we had a lightweight force-sensitive resistor and 100 grams of weight inside. Both baskets were tied together with a monofilament string and attached to a pulley for minimal resistance. The 200-gram basket was then raised to one meter above the ground. The basket was then dropped and the reading of the force-sensing resistor was recorded. In a perfect environment, the amount of force recorded should be the same as double the resting weight being applied. We observed that through 50 drops the average value was around 50% more than that of the original force. Despite being around only 50% of the projected value, this still exemplified Newton's third law, albeit with many external factors such as air resistance, friction in the pulley and imprecise force readings. These findings imply that the concept of a 1g rocket based on Newton's third law is applicable. This shows that the weight of an object can be artificially manipulated using these laws and thus be used as artificial gravity. The concept shown in this experiment can be used in long-term spaceflight to negate some of the negative effects low gravity has on the anatomy of a human.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** PH EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 172 | PST | 6508 |

**Title:** The Development of an Auto-Disable Syringe to Combat the Spread of Bloodborne Diseases via Intravenous Injection Drug Use

**Student Name(s):** A. Marks, S. Guadalupe

**Abstract:**

The purpose of this engineering project was to design and prototype a fixed-needle, auto-disabling syringe for potential distribution by syringe-exchange programs in order to combat the spread of bloodborne diseases. The first phase consisted of research and interviews with professionals of the drug intervention industry. After, the second phase consisted of the designing of a prototype syringe in the software Fusion360. The two main principles of the design process were deduced as follows: each syringe can only be used once, and the mechanism in place to accomplish that task must be impervious to human force or will. The third phase consisted of 3D printing the prototype syringe and performing various tests to determine its effectiveness in both function and prevention of reuse. These tests included utilizing a liquid proxy to assess each prototype's ability to uptake the proxy as well as utilizing a force gauge to measure the force needed to bypass the lock mechanism. During this phase, previous prototypes were altered in order to optimize prevention of reuse.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** ME AT EN

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 240 | PST | 6510 |

**Title:** Creating a Platform Capable of Conveying News Article Bias

**Student Name(s):** P. Scully, J. Feuerstein

**Abstract:**

Today, people of differing political ideologies tend to get their information from different sources and often have very different opinions of bias. Fortunately, computer science already has the potential for more objectively analyzing media bias. The purpose of this project was to take advantage of this and create a platform capable of dissecting articles in the context of bias and factual integrity, conveniently and succinctly conveying this information to a user.

The constraints of this project were limited time, lack of extensive knowledge or experience in design and application programming, and a lack of money to buy expensive design software. The criteria were that the platform accurately assesses bias and has a functional and user-friendly user interface. The application was programmed modularly, such that features were sequentially programmed and integrated upon readiness.

The application was programmed in Django, a Python-based open-source and free web framework, utilizing the React Native typescript library. Bias is assessed by comparing the text of articles to a list of biased words aggregated by researchers from Stanford. All source code is hosted in a GitHub repository, and all UI/UX design was done in Figma. All work with the mentor was in code reviews and advice -- no direct progress was made by the mentor.

If effective, this application will have the potential to aid in reducing the divisiveness of current politics and social issues, possibly leading to a more educated and civil future.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 249 | PST | 6511 |

**Title:** Analyzing the Ability of the SCiO Spectrometer to Detect the Presence of Phosphorus in Soil

**Student Name(s):** M. Dunphy, K. Wilkenloh

**Abstract:**

The SCiO spectrometer offers gardeners and farmers a quicker, more cost effective way to analyze the contents of soil. The SCiO, a pocket sized spectrometer is normally associated with the analysis of food, however this experiment seeks to expand the use of the SCiO spectrometer to the agricultural field. This poses the question: does the SCiO spectrometer have the ability to accurately analyze the presence of phosphorus in soil? In the first phase of the methodology, soil samples with unknown phosphorus concentrations were collected from 5 different sites. Next, the samples were scanned using the SCiO and uploaded to the developers forum for analysis. In the final phase, the scans were compared with results from a soil test kit and soil fertility lab to determine if different concentrations of phosphorus are accurately differentiated by the scans. The scans of the soil samples are clearly differentiable in the developer's forum and when assigned a classification of phosphorus content as low, medium, or high they are situated with the scans of their classification. Consequently, the results convey the ability of the SCiO to accurately determine levels of phosphorus in soil. The experiment serves as an example of the SCiO's capabilities beyond its traditional uses in the food industry. The SCiO can be extremely useful to gardeners and farmers who seek to determine the health of their soil in terms of nutrients and now have access to a reusable soil testing device that can analyze a variety of different things about soil.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EV EA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 189 | PST | 6512 |

**Title:** Harnessing and Repurposing Processing Heat Gradient Produced by a Computer to Reduce the Battery Lost to a Cooling Fan

**Student Name(s):** G. Kapp, M. Montgomery

**Abstract:**

The purpose of this project was to harness excess heat from laptops to increase their efficiencies by converting the temperature gradient into usable electricity, which can then be incorporated back into components of the computer to increase battery life. The process was separated into three different aspects: the Peltier plates, the computer, and the application of the energy into the fan or USB port. Each of the components was tested for power input and output in order to create an ideal image of the effectiveness of the apparatus. The computer was tested under stress conditions in order to find the running temperature, which was then used to check the voltage levels that could be attained at these temperatures. The computer's battery life was then tested with and without the fan running, to determine the necessity of the electrical recycling. This power from the temperature gradient was used to power an iPhone confirming the effectiveness of the system. Finally, the plates were wired to the fan such that when the computer reached a certain temperature, the necessary voltage would be produced by the gradient, and the fan would turn on.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT EE

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 248 | PST | 6513 |

**Title:** Creating an Optical Fiber Daylighting System for Hydroponics With Raspberry Pi Active Dual Axis Solar Tracking

**Student Name(s):** P. London, A. Kongani

**Abstract:**

Hydroponic farming (HF), an indoor farming method, has demonstrated potential to be the future of the agriculture and food production industry. HF reaps massive benefits; however, installing hydroponic lighting systems or greenhouse environments is expensive and requires resources like electricity, making HF inaccessible for many. The purpose of this project was to create an adaptable, low cost and maintenance optical fiber daylighting system for HF. This project created both a solar collection (SC) and a tracking system (TS). Development was split between two partners. One student created the TS using a Raspberry Pi and electronic hardware. A Python program used light-dependent resistors as input and adjusted servo motors accordingly to accurately track the sun. The other student constructed a dual-axis SC rig that provided a frame and mobility for a Fresnel lens that was used to focus light into an optical cable. Throughout development, the mentor provided oversight and guidance virtually. After construction, the effectiveness of the combined system was analyzed based on mobility and accuracy of tracking.

The frame was able to track an illumination source up to 280° throughout the day and 250° for seasonal change. Using a coated fiber optic cable also reduced intrinsic attenuation and light loss. Additionally, the $200 price tag is much more affordable than existing illumination systems. Continuing to promote the use of hydroponics and developing our design will provide an avenue to attain inexpensive, efficient, and environmentally-friendly farming with the ultimate goal of making HF accessible worldwide.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE AT

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 122 | PST | 6515 |

**Title:** Reduction of Atmospheric Carbon Dioxide via Production of Ammonium Carbonate:

The Creation of a Novel, Aqueous Carbon Sink.

**Student Name(s):** H. Sorbaro, C. Officer

**Abstract:**

The objective of this project was to investigate the bonding of carbon dioxide to ammonium hydroxide as a means to efficiently reduce atmospheric CO2 through the production of ammonium carbonate and the creation of an artificial carbon sink. The process entailed carbonating the NH4OH and evaporating the created solution at 550ºC to dissipate unreacted NH4OH. The remaining ammonium carbonate solid was collected and massed in various trials to allow for the calculation and determination of the amount of CO2 removed from the ambient atmosphere. Results indicate the process does in fact remove carbon dioxide from the atmosphere, however, the produced solid was produced in negligible amounts, highlighting the inefficiency of the system when compared to the energy input required to run it.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** CH AT EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 173 | PST | 6516 |

**Title:** An Investigation of Current-Powered, Aquatic Turbines as an Alternative Energy Source

**Student Name(s):** T. Danforth, F. Williams

**Abstract:**

The purpose of this project was to design a hydrokinetic turbine that uses ocean currents to generate electricity as a renewable energy source that does not pollute the environment. Initially, differently shaped prototypes blades and blade hubs were designed and printed using a 3D printer. The tower and nacelle were constructed using PVC pipes and a plastic tripod base, and steps taken to prevent water from entering the generator including covers, sealing of the seams using silicone 3D printed end caps. The testing tank contained a water pump that was used to push water into the blades to simulate ocean currents and the inlet value used to recirculate the water during testing. Various water pressures as well as various blade prototypes were tested in specific time intervals by collecting energy output using a multimeter. At the conclusion of data collection, blade prototype #3 proved to produce the most energy as compared to the other prototypes. We believe size upscaling of our prototype is a viable method to harness potential energy of ocean currents.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE AT EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 165 | PST | 6517 |

**Title:** Creating a Renewable Energy System Powered by Pressurized Gas to Limit Production of Greenhouse Gases

**Student Name(s):** H. Spiess, C. Eschricht

**Abstract:**

The purpose of this project was to create a renewable energy system operating in a closed environment that utilized pressurized gas and aquatic turbines to produce cost-efficient, clean energy. It was hypothesized that if pressurized helium rises the fastest, as a result of its low density, the impulse turbine can most effectively capture the potential energy stored within the pressurized gas. The prototype system was built in a 14 x 9 x 11 inch, water-proof container. An inlet for the generator and attached turbines, as well as an inlet for the gas-release valves were added and water-proofed on the sides. Prior to testing, various prototypes of 3D printed turbines were created to optimize energy production. Data collection included a comparison of energy output using the three different gases as well as a comparative-analysis of the efficacy of the turbine prototypes. After statistical analysis, data suggests that helium gas, when used with prototype turbine #3, produced the largest amount of energy.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE

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# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 245 | PST | 6518 |

**Title:** Removal of Phenol from Drinking Water Utilizing Food-Derived Activated Carbon Combined with Nickel (II) Oxide

**Student Name(s):** E. Chang, J. Silbert

**Abstract:**

Phenol is a highly toxic aromatic compound frequently released into the environment via various anthropogenic sources, such as wastewater. Activated carbon (AC) and nickel (II) oxide have both been shown to be effective phenol adsorbents. AC can be sourced from biomass like food waste, making it a very sustainable and desirable sorbent. This project aimed to utilize food-derived AC combined with NiO to filter phenol from drinking water. The mentor conducted batch experiments by placing several AC/NiO sorbents into phenolic solutions over periods of 24 hours. The sorbents differed in their ratio (by mass) of AC and NiO. These experiments yielded data about the adsorption capacity (in mg/g) of the sorbents. The students used this data to determine if the varying sorbent compositions produced statistically significant differences in sorbent capacity. Findings thus far have indicated that the addition of NiO to an AC sorbet does not significantly hinder or improve sorbent capacity. Further research on different ratios of AC and NiO must be tested, however, as they may yield different conclusions. The findings of this project may lead to innovations that more effectively purify water and support public health. Additionally, by utilizing biomass in a sustainable manner, less biomass may need to be placed in landfills, thereby lowering the demand for deforestation and excavation. Decreased environmental damage will, in turn, leave more trees standing to absorb atmospheric carbon dioxide and lessen the impact of the global greenhouse effect and other environmental concerns.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EV CH

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# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 89 | PST | 6519 |

**Title:** The Efficiency of Newer and Older Aircraft Designs

**Student Name(s):** D. Cammarota, M. Markowsky

**Abstract:**

Many aerospace companies are designing new, innovative aircrafts in hope to save gas and money. In this experiment we will be testing the aerodynamics of 2 newer designs and 1 more generic aircraft design to see if these new and innovative designs are numerous times more efficient than the older design. To test the aerodynamics, we made 3d scale models of the Maverick by Airbus, the Celera 500l, and the New Midsize Aircraft by Boeing (NMA). And we will test ad compare lift and drag using a wind tunnel.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** EE PH

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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# CSEF Official Abstract and Certification

| Word Count | Fair Category | Project Number |
|---|---|---|
| 251 | PST | 6520 |

**Title:** Biomimicry of Whale Baleen to Remove Microplastics from Water

**Student Name(s):** J. Guo, Y. Shirai

**Abstract:**

Microplastics are small fragments of plastic less than 5 mm that prove detrimental to the marine environment. These grains of plastic are formed when larger plastic pollutants degrade by, forming POPs, or persistent organic pollutants. At least 690 marine animals have been physically impacted by POPs, which can block the digestive tract when consumed. Some microplastics contain toxins from the manufacturing process that threaten the health of marine organisms.

The purpose of this project was to design a new apparatus to remove microplastic pollutants from marine environments. This apparatus is inspired from the suction-feeding system of baleen whales, which is effective at gathering small, scattered prey. The hope is that by using biomimicry of an already established system in nature, the new apparatus will prove to be more effective than already existing methods to remove microplastics.

The development of this project can be separated into two phases. In phase one of the project, research was conducted to construct a model of the apparatus. After sketching out a preliminary design on paper, the design was recreated digitally using a CAD software. In phase two of the project, the practicality of the model was tested and the original model was refined. Whereas the initial model was spherical in shape, the new model was conical in shape to decrease drag as the apparatus traveled through water. A second filter was added to the inside of the apparatus with openings 1 mm apart in order to decrease the possibility of collecting any other debris.

**Technical Disciplines Selected by the Student (Listed in order of relevance to the project)** AT

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4. Is this project a continuation? ☐ Yes ☒ No
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