73rd Annual Fair

Connecticut Science & Engineering Fair

March 8 - 20, 2021

Student Abstracts

Applied Technology

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
273	LS	3037

Title: Rapid, Noninvasive, Fluorescence-Based Detection for Elevated Levels of Nitric Oxide in Exhaled Breath, As a Marker for Hazardous PM2.5 Exposure

Student Name(s): A. Grover

Abstract:

There is a clear correlation between prolonged exposure to ambient fine particulate matter (PM2.5) and the development of lethal disease. Today, there exists no personalized, quantifiable measure to gauge an individual's exposure to PM2.5 other than generalized tools. PM2.5-induced constriction of lung airways leads to elevated NO levels produced in the lungs to fight inflammation. Accordingly, excess concentration of NO (40+ ppb in adults, 25+ ppb in children) can be a viable breath biomarker for the indication of PM2.5-induced lung inflammation. Herein, an inexpensive, portable, rapid, and temperature-independent breath detection kit for PM2.5 exposure was developed, based on smartphone-detection of NO-induced luminescence of DAF-2 (diaminofluorescein-2). Upon exposure to NO, DAF-2 is converted to highly luminescent DAF-2T (exc/em 485/530nm), which acts as a positive indicator for elevated breath NO levels due to PM2.5 exposure. To begin, 8 µl of 50ug/ml DAF-2 was embedded onto a filter-paper-based detection card, which was found to be stable when stored at room temperature (via repeated FTIR analyses). A linear relationship between 60ml of 0-1000ppb NO breath concentrations and DAF-2T detector illumination was established, first via surface-luminescence spectroscopy, and later with Smartphone images, taken with 490/560nm bandpass filters, for the flash and camera, respectively. A Smartphone application rapidly converts the detection card images (DAF-2 blank versus breath, NO-induced DAF-2T image) to green-color values, with a written algorithm determining the NO-breath concentration down to 10ppb. These results are time-stamped and shared, along with GPS coordinates, to build live PM2.5 exposure trends, at a per-test cost of ~$5.

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):

☐ 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	LS	3040

Title: An economically feasible application of germicidal irradiation to Personal Protective Equipment

Student Name(s): J. Fels

Abstract:

The purpose of this project was the development of a novel, economically feasible device capable of engendering germicidal irritation on bacteria cultures developed from used Personal Protective Equipment in economically underserved areas of the world. The procedure testing the device was conducted in two phases: bacterial control, and UVC implementation. In the former, individual pieces of PPE were inoculated with a K-12 strain of Escherichia coli, and then swabbed, with that bacteria cultivated and observed on a growth plate. In stage two, PPE was again inoculated with the strand, but then subject to 270 nm of UVC radiation via my apparatus. This process was observed at separate intervals of 5, 30, and 60 minutes. After exposure, the bacteria from the PPE was subsequently swabbed, cultivated, and observed and a comparative analysis against the control groups conducted. At the conclusion of statistical analysis, results indicate that this economical UVC irradiation apparatus is a feasible option for use of germicidal irritation on used PPE with the goal of reuse and sanitation.

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

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CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
235	LS	3074

Title: Implications of Tyrosine Kinase Inhibitors Used Primarily for Non-Small Cell Lung Cancer on Various Bodily Systems Predicted Through Pathway Functions and Gene Expression.

Student Name(s): S. Adams

Abstract:

Afflicting many individuals with non-small cell lung carcinoma, epidermal growth factor receptor (EGFR) alterations are present in a relatively significant number of patients with the illness. EGFR has a large presence in cell-to-cell signalling and as a result is strongly connected to a myriad of systems in the human body, with a significant impact in organs with high EGFR expression. The protein itself can be linked to many other downstream pathways leading to a diverse set of effects. Most directly, EGFR takes an active part in mediating cell proliferation and mitigation. In cells with EGFR mutations, the overexpression of EGFR can lead to excess cell proliferation and formation of tumors. In response, drugs have been developed to inhibit EGFR function in an effort to staunch cancerous growth. This research takes a broad look into the side effects of both reversible and irreversible tyrosine kinase inhibitors (TKIs), including Erlotinib, Gefitinib, Osimertinib, and Afatinib amongst others, as used for the inhibition of EGFR. Utilizing databases including the Kyoto Encyclopedia of Genes and Genomes (KEGG), AmaZonia!, and PubMed, information was used to summarize and organize data concerning EGFR function to form predictions on cell activity and organ function. The findings suggest that processes involving restoration and maintenance are likely to be impaired, and a reduction in other bodily activities including inflammation and fibrosis can be seen among other effects as a result of EGFR inhibition.

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

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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
151	LS	3077

Title: Are Phones Bad for You?

Student Name(s): Z. Choudhry

Abstract:

In order to determine if cell phones released electromagnetic radiation and to also determine whether electromagnetic radiation negatively affects humans, we decided to measure the amount of electromagnetic radiation that was released by a cell phone in hertz, when being called, over the distances of 2 cm, 5 cm, and 15 cm away from a radio frequency (RF) meter. For each distance, we decided to run three trials and we also averaged the results of all three trials per distance. After this, we would compare this data to the amount of electromagnetic radiation that causes negative effects to the human body such as sleep disorders, concentration issues, cardiovascular disorders, and memory loss. After conducting this experiment, our team was able to conclude that phones do release electromagnetic radiation and that the amount of electromagnetic radiation that is released by phones does not cause any of the mentioned negative effects on humans.

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

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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
209	LS	3091

Title: Active Aeration of Hydroponic Systems.

Student Name(s): A. McLaughlin

Abstract:

Objective :Hydroponics is a novel way of growing food. Hydroponics grows plants with roots suspended in water. Growing in buckets of water allows precise control of the growing medium giving the farm a way to reduce waste of water and nutrients. Aquaponic technology is a growing field of research because of its increasing use in the agricultural sector. Because oxygen content influences rooting depth active aeration was tested as a way to increase growth.

Methods: Two groups of arugula were grown in containers of water, pearlite and fertilizer. The experimental group was bubbled 24/7. The control group had stagnant water. 6 week old plants were removed and measured for mass and length..

Results: The average length of the experimental group was 5.5 cm. The average length of the control group was 3.3 cm. Mass was never taken because every arugula combined did not register on my scale. The survival rate of the experimental and control was 38% and 16% respectively.

Conclusion: This study cannot draw strong conclusions. Many plants never germinated. Molds and algae contaminated both groups. Nevertheless, the experimental group had algae, which probably comprised a majority of the biomass and survived better against the onslaught of diseases. Perhaps that means aerated water is better for plant life.

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

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CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
207	LS	3104

Title: Designing a Blood Alcohol Tracker through Transdermal Alcohol Content to More Accuratley Test BAC

Student Name(s): W. Klein

Abstract:

The purpose of this project was to build a more accurate Blood Alcohol Content (BAC) testing system using Transdermal Alcohol Content (TAC). Upon drinking alcoholic beverages, ethyl alcohol is metabolized and is eventually secreted from the sweat glands. The level of alcohol embedded in the sweat is known as TAC. Today, modern breathalyzers can be an unreliable reflection of one's BAC. For example, unmetabolized alcohol in your stomach and oral cavity can lead to a higher BAC reading, while actions such as exercising, holding your breath, or hyperventilating can reduce a BAC reading. The transdermal device was created to more accurately measure BAC. Using a pilocarpine hydrogel to stimulate neural pathways in the sweat pores, secretions were collected using a 3-D printed wrist clamp and sickle shaped sweat collection device with an attached syringe. Collected liquid was run through a filter containing an alcohol oxidase hydrogel to separate hydrogen peroxide produced by the ethyl alcohol embedded in the sweat. Finally, a combination of a Bleach reagent #1, Maligdate reagent, and Via Sulfate reagent were used to measure the ppm of hydrogen peroxide in a sample. Data indicates that the created device and reagents can accurately measure levels of hydrogen peroxide, therefore producing an accurate BAC reading.

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

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
265	LS	3111

Title: Prolonged, Smart Treatment of Multi-Drug Resistant Bacteria of Chronic Wounds via an EGCG-AgNP HydroMed Dressing

Student Name(s): Y. Sakai

Abstract:

In the US alone, 6.5 million people are affected by chronic wounds each year, and the burden on the healthcare system is $25 billion annually. Chronic wounds are of particular health risk to those with immunocompromising conditions, where 90% become multi-drug resistant due to subsequent biofilm formation. Current methods to prevent wound biofilm formation are limited in effectiveness, given the prolonged protection times needed, and the ever-changing nature of a wound. Accordingly, this research has developed a prolonged, smart dressing, where silver nanoparticles (AgNP) and epigallocatechin gallate (EGCG) were embedded into a HydroMed (Hm) hydrophilic polymer (at a 1:1:40 mass ratio) via ethanol dissolution. In an aqueous simulation of a constant-exuding wound, embedded AgNPs and EGCG were shown to consistently release from the Hm dressing for at least 24 hours. While each dressing component exhibited antibacterial properties on a simulated, already-infected wound for 24 hours (Hm: 31%, Hm-AgNP: 61%, and Hm-EGCG: 55% inhibition of H157-O7 E. coli), AgNP and EGCG acted synergistically in the smart dressing to inhibit ~70%. To simulate application of the smart dressing onto a freshly-cut wound, and demonstrate its "smart" properties (the dressing shrinks/dries upon wound closure, and reswells/re-releases antibacterials upon accidental wound reopening), 400mg dressing was placed into a freshly-inoculated E. coli culture. After 4 hours of simulated wound drainage, and 74% E. coli inhibition, the dressing was removed, dried, and reapplied to a newly-opened wound simulation. With reswelling, the AgNP-EGCG-Hm smart dressing was found to inhibit 78% E. coli for an additional 4 hours.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
250	LST	3504

Title: Development of a WatchOS Application that uses HRV and Vibrational Pulses to Reduce Stress

Student Name(s): S. Munim, A. Liu

Abstract:

Stress is a reaction that can negatively affect many people, and it has a strong correlation to Heart Rate Variability (HRV), a measure of the variation in time between each heartbeat. Research shows that vibrational pulses can reduce stress and increase HRV. The application that was created helps reduce this stress and increase HRV for people that are negatively affected. To test the application, participants were split into 2 groups, A and B, who remotely completed a stressful task of summarizing an article in the time span of 10 minutes. During the task, Group A did not revive the vibrations whereas Group B did. Before and after the task, a VAS Questionnaire was given to measure anxiety and stress levels. HRV was also measured using the application during the task. Analyzing the VAS Questionnaire, HRV averages, and task scores, the preliminary data suggests that Group B, which had received the vibrational pulses had a higher HRV and task score, while maintaining a lower result on the VAS Questionnaire. A lower score on the VAS Questionnaire signifies less stress. Greater implications of this application are to add features such as custom haptic responses, night time vibrations to enhance REM sleep, and to send vibrations when it detects irregular HRV. A separate device can be created using HRV and vibrational pulses to make the technology more affordable for people without apple watches. These implications intend to increase HRV and reduce stress, with the aspiration of improving wellbeing for people across the world.

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

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CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
219	LST	3514

Title: Regenerating Transformed Plant Cells Expressing Algal Cytochrome C6 to Increase Photosynthetic Yield in Plants

Student Name(s): M. Konzerowsky, A. Arjomand

Abstract:

The objective of this project was to increase photosynthetic yield by successfully transforming flowering plants with the addition of cytochrome C6 plasmid. Arabidopsis thaliana, Nicotiana x sanderae, and Vigna unguiculata were three plant species selected for the study. The plants were grown in similar environmental conditions with a sixteen-hour photoperiod, moderate humidity and temperature, regular watering, and nutrient supplementing. Three methods of plant cell transformation were studied in a comparative analysis. In the first method, plant cells were exposed via infiltration dipping to Escherichia coli carrying the selected cytochrome C6 plasmid. (The selected plasmid also contained a short sequence for spectinomycin resistance in order to confirm plasmid uptake.) In the second method, the cytochrome C6 plasmid was isolated from a strain of E. coli and transformed into Rhizobium radiobacter (Agrobacterium tumefaciens), a bacterium with an affinity to plant tissue, followed by infiltration dipping of targeted plants. In the third method, the plant cells were directly dipped into an infiltration medium containing only the purified target plasmid with no bacterial vector. Select tissue leaflets were cut from each plant, dipped in the infiltration media, and grown on spectinomycin/agar plates. The remaining structure of the arabidopsis and tobacco plants were then entirely submerged in the infiltration media and were allowed to set seeds to be germinated on agar plates.

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

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
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☐ Yes ☒ No

CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
246	LST	3515

Title: The Striking Strawkin Duo

Student Name(s): N. Bolineni, S. Yang, R. Bansal

Abstract:

The purpose of our project is to be able to test for benzodiazepines(date rape drugs) as discreetly and quickly as possible. Our experiment has two components: a straw and a napkin. The straw will be a normal pre-made collapsible straw with a hole that will dispense the water from the cup and will pour onto a napkin. This napkin will be made up of three layers. The middle layer will be soaked and dried in cobalt thiocyanate. Cobalt thiocyanate is a color test that will detect many drugs which all fall under the benzodiazepine category. Examples include cocaine, ketamine, etc. This would be our proposed plan for testing:

Steps:

1. Soak the middle part of the napkin in (trials 1 ml, 2 ml, 3 ml, 4 ml, 5 ml, 6 ml, 7 ml) of Cobalt Thiocyanate until the solution is absorbed.
2. Place on drying rack until completely dry (trials: 1 day, 2 days, 3 days, 4 days)
3. Layer the bottom and top layer of the napkin on the absorbed tissue and use plastic to iron the corners and the sides shut.
4. To test if it would work we would've poured 2 ml of benzodiazepines on it as well as benzodiazepines mixed in water.

This is only a theory-based method. The entire project will be based on data and research and will be considered a theory.

Our data will be in a journal for you to follow along with our process.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
242	PT	4003

Title: Toilet Power: Capturing Wasted Energy from Home Fixtures

Student Name(s): L. Marshaus, C. Walker, F. Lamattina

Abstract:

The objective of our experiment is to convert kinetic energy from the inlet valve filling a toilet into electrical energy to charge a phone. Our initial inspiration was to move away from fossil fuels using wasted energy, which we succeeded in demonstrating during experimentation. When the toilet fills with a relatively fast flow, about 1.7 gallons/minute, it presents the opportunity to convert kinetic energy from the toilet's water flow into electrical energy that could be used for practical purposes. This has been done to an extent in Hong Kong in 2013 when wasted water from a shower drain was utilized for other needs. We connected a water turbine between the inlet valve and the holding tank of a toilet. Each flush resulted in the tank being refilled with water in approximately 48 seconds, producing a continuous charge up to 12 volts during the refill. In addition, we added a disassembled car charger rewired to connect the turbine to the phone. The car charger is used to limit the voltage so that the phone does not get damaged. Once the turbine and phone are properly connected and assembled, we flush the toilet and get an indicator that the phone is successfully charging. One flush may not fully charge a cell phone, but multiple flushes over time can fully charge a phone. For example, if one were to circuit-together multiple toilets in a large complex, substantial amounts of energy could be generated.

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

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
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☐ Yes ☒ No

CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
252	PT	4004

Title: How Thermoelectricity Can Improve Warmth in Colder Climates

Student Name(s): R. Wilson, J. Cieslak, O. Kolb

Abstract:

The objective of this project was to discover if human body heat, converted by a thermocouple, could produce enough electricity to power a resistor. The resistor would then warm a boot, making it more comfortable to wear in cold temperatures. Thermocoupling creates electricity by utilizing the Seebeck Effect, which works by harnessing the energy created by the difference in temperature between two pieces of metal.

The thermocouple used was attached to a Nickel-Chromium resistor circuit, contained between a layer of rubber foam and silicone. The resistor was placed in the sole of the boot. The thermocouple's probe was heated with 37°C water contained inside a sealed plastic bag. To take advantage of the temperature difference between the inside and outside of the boot, the output end of the thermocouple was moved closer to the outside of the boot, allowing the colder air to cool the thermocouple. Using a thermometer, we tested the heat output of the resistor several times with different thermocouples but with a consistent water temperature.

After comparing results, we discovered that K-Type thermocouples made with Nickel-Chromium and Copper wires produced the most electricity, but were less practical because the probe needed to be heated evenly. Conversely, a T-Type, made of constantan and copper, needed less equal heating and was easier to work with but produced less electricity. A thermocouple and resistor could produce enough heat to warm the wearer, although further testing is needed to identify the type of resistor that would be most effective.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
252	P7	5002

Title: A Covid-19 Social Distancing Device Using a PIR Motion Sensor and a US-100 Ultrasonic Distance Sensor

Student Name(s): S. Srinivasan

Abstract:

Social distancing has become a huge part of our lives in the past year. It is critical we keep ourselves safe to prevent the number of Covid cases from increasing further. My device assists in doing so by calculating how close the user is to another person nearby. This device comprises of two major components: a Passive Infrared (PIR) motion sensor and a US-100 ultrasonic distance sensor. This product allows the user to customize the distance in feet they want to be socially distanced, and can also arm or disarm the system as needed. When the device is armed, the motion sensor checks for movement within its range. Once motion is detected, the US-100 calculates the distance between the user and the person nearby. If this value is greater than the distance configured by the user, an RGB LED turns green, indicating that the user is in a safe zone. If not, the LED turns red and a text alert is sent, informing the user how close he/she is from the person nearby. As a test for accuracy, I used a measuring tape to find the actual distance between the device and a moving object and compared it to the distance calculated by the device. I performed this experiment for ten days and recorded the results. Overall, my device is fairly accurate and is only 2-3 inches off at most. In the future, I plan on creating a simple mobile app to make user interaction with my device easier.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
176	P7	5008

Title: Remote Learning on a Budget

Student Name(s): J. Benin

Abstract:

During the COVID-19 Pandemic, online learning has become a key factor in our education. Some families have had trouble supplying their kids with the resources they need to learn virtually. Thanks to my research and testing there is a way to not spend a fortune on a computer, but still be able to learn! A Raspberry Pi is a low-end computer that is very inexpensive. I bought a Raspberry Pi 4 and tested the things you would do when you learn online. It could easily complete the tasks. I measured the difference between a high-end Windows 10 desktop and the Pi. The Raspberry Pi was only a few seconds slower than the Windows 10 computer and it was able to perform all of the tasks needed for middle school virtual learning. While the Pi is also able to do some more advanced things like programming and 3D modeling, these tasks will go considerably slower. The Pi runs on a Linux operating system, so some games aren't supported (such as Microsoft Flight Simulator 2020).

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

Word Count	Fair Category	Project Number
240	P7	5012

Title: Metal Hardening: Heating, Hammering and Holding Atoms Together

Student Name(s): A. Campbell

Abstract:

Metals make up over 30% of earth. Metals can be found in buildings, cars, appliances and more. Work hardening is a process where metals are heated up, cooled down and hit with a peening hammer. When the metal is heated, the atoms move faster and spread out. For metals with low melting points the atoms spread out so far they become a liquid for a short time and then reform into a solid. For metals with high melting points liquefying can take a long time and needs immense heat to happen, so the heated metal only softens. While the metals are hot and in a soft state, a peening hammer is used to force the atoms back together in a new structure. The peening hammer has a rounded tip for concentrated hits and the peening hammer focuses the energy on the metal surface and pushes atoms together. My hypothesis was that alloys when work hardened would be harder than the individual metals when work hardened, which was found to be true.

Copper, tin, zinc, bronze and brass metal coupons were work hardened. Scratch testing using metal hardness files was used to compare the hardness of individual metals, work hardened metals, and alloys. The alloys used were bronze and brass. Bronze contains copper and tin and brass contains copper and zinc. Some of the individual metals became harder while others did not change in hardness. Both of the alloy's hardness increased.

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):

☐ human subjects ☐ potentially hazardous biological agents
☐ 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
255	P8	5501

Title: Implementation of Metal-Oxide-Induced Agglomeration and Electromagnetic Filtration for Removal of Microplastics

Student Name(s): S. Mohanraj

Abstract:

Microplastics, nondegradable fragments of plastic debris less than 5mm in size that arise from the breakdown of consumer products, are persistently found in water sources and pose health hazards to all species. Their microscopic size renders them difficult to remove using conventional water purification processes.

This project investigated using novel electrically-driven methods to agglomerate and remove microplastics from contaminated water samples. Three methods were analyzed: electrically-magnetized filtration, electrically-magnetized filtration enhanced by the addition of metal (iron, manganese, nickel) oxides into the contaminated water samples to better agglomerate microplastics, and electrolysis. It was hypothesized that enhanced filtration would be most effective due to metal oxides' agglomeration with microplastics, allowing microplastics to be attracted to the filter, iron oxide being the most effective oxide due to strong magnetic properties.

Microplastics (HDPE, PETE, PP) were each added to distilled water to create separate samples, along with a sample of washing machine discharge containing microplastic fibers from synthetic cloth. These were assessed using three analyses prior to and following the above agglomeration methods: spectroscopic analysis (using Beer-Lambert's Law to determine the extent of filtration of suspended microplastics from the samples), microscopic analysis (quantifying the number of microplastic fragments within the samples), and turbidity tube analysis (determining turbidity levels).

In all three analyses, the implementation of iron oxide with the electrically-magnetized filter, removing about 50% of microplastics, worked most effectively in all microplastic samples compared to all other methods. The electrolytic cell worked the least effectively out of all the methods, removing only about 7%.

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

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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

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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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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

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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

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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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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

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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

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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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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.

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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

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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

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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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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
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

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☐ 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):

☐ 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
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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☐ 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

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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
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

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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

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☐ 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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☐ 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

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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
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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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

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☐ 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):

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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
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

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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
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

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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
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

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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
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

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☐ 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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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	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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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):

☐ 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
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):

☐ 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	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

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