CONNECTICUT SCIENCE & ENGINEERING FAIR

78th Annual Fair
March 2-14, 2026

Student Abstracts

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

2026

Word Count	Fair Category	Project Number
251	PS	6001

Title: Developing a Climate Finance Vulnerability Index (CFVI) for Connecticut to Identify Communities with High Climate Risk and Disproportionately Low Recovery Funding

Student Name(s): J. Chen

Abstract:

Climate change is intensifying as seen through the increased frequency and severity of climate related disasters. Greater exposure, loss, and barriers to recovery after climate-related disasters are experienced by more socially vulnerable communities. While prior vulnerability indices quantify exposure and social risk, they rarely incorporate actual disaster-recovery funding, limiting evaluation of whether resources are equitably distributed. This study develops a Climate Finance Vulnerability Index (CFVI) for Connecticut to assess whether communities with higher composite need, defined as the interaction of hazard exposure and social vulnerability, receive comparatively less disaster recovery funding. Social vulnerability indicators were pulled from the CDC/ATSDR Social Vulnerability Index (2022). Hazard exposure was pulled from the FEMA's National Risk Index, aggregated from the census tract to the planning region level. Disaster funding data was compiled from FEMA Public Assistance (PA v2) and Individual Assistance Housing datasets (1998–2024). All data was then normalized, and converted into funding-to-damage ratios. Regression analyses were run for composite need score vs finance score to evaluate alignment between composite need scores and funding outcomes across Connecticut's eight planning regions. The results indicated a low correlation between composite need and disaster funding ($R^2 = 0.1733$) which was not in support of the hypothesis. This suggests that allocation of financial resources is not proportional to the funding, where where some high-need regions are adequately funded while others remain under-supported. These findings align with prior research highlighting administrative complexity, eligibility constraints, and informational barriers as drivers of inequitable recovery outcomes.

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

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

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

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

☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
248	PS	6003

Title: Fleet for Localized Atmospheric Research and Environmental Surveillance (F.L.A.R.E.S.)

Student Name(s): T. Bhattacharya

Abstract:

FLARES aims to address the limitations of traditional stationary air quality monitoring systems, which often fail to detect localized pollution spikes and sudden hazardous events in real time. It reduces the delay and inaccuracy associated with fixed-threshold alert systems by integrating intelligent anomaly detection into environmental monitoring frameworks. The system operates in three primary stages: 1) data acquisition, 2) anomaly detection processing, and 3) alert visualization and future deployment integration. To collect data, FLARES utilizes publicly available environmental air quality datasets containing quantitative metrics such as particulate matter (PM2.5), carbon monoxide (CO), temperature, and humidity levels. These datasets simulate the continuous data stream that would be obtained from onboard sensors in a mobile monitoring platform. The collected data is processed using a machine learning anomaly detection algorithm, specifically an Isolation Forest model, trained to identify abnormal pollution patterns without relying solely on fixed regulatory thresholds. The performance of the AI-based model is then compared to a traditional threshold-based detection method to evaluate differences in false positive rates, detection sensitivity, and responsiveness to pollution events.

After processing, detected anomalies are flagged and visualized through time-series analysis, demonstrating how intelligent classification can enhance environmental awareness and response capabilities. By validating the effectiveness of AI-driven anomaly detection, FLARES establishes a computational proof-of-concept for future integration into autonomous drone-based monitoring systems. This approach supports the development of scalable, high-resolution environmental surveillance tools capable of improving localized air quality management and public health response.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
57	PS	6004

Title: All-Purpose Arduino Tracker

Student Name(s): F. Figueiredo

Abstract:

The purpose of this project was to use iterative design to create a GPS tracking system. Current commercially-available solutions leverage phone bluetooth technology and rely on other devices. This system was built with ardiunio architecture using a Neo-6M GPS Module and coded in C++. This system has the advantage of non-reliance on other devices.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
241	PS	6007

Title: Integrating Vision-LLMs and RAG for Adaptive Alzheimer's Assistance

Student Name(s): E. Joseph

Abstract:

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by heterogeneous cognitive decline, including episodic memory loss, semantic impairment, visuospatial dysfunction, and prosopagnosia. While existing assistive technologies primarily emphasize reactive safety, they lack proactive, context-aware semantic support and often rely on cloud-based processing, raising privacy concerns. This study presents the development and evaluation of a fully offline, privacy-aware multimodal mobile assistant designed to mitigate object and face recognition deficits in individuals with AD. The system integrates MobileVLM-3B deployed via llama.cpp for on-device multimodal reasoning, a FaceNet-based biometric pipeline with MTCNN face detection for prosopagnosia support, and ChromaDB for on-device retrieval-augmented generation (RAG). All components operate locally using quantized GGUF models and memory-mapped inference to ensure efficient execution within 6–12GB mobile RAM constraints. A voice interface enables hands-free interaction using native on-device speech recognition. Evaluation across 2,149 clinical records demonstrated that the RAG-based framework achieved an F1-score of 0.933 in cognitive state identification, significantly outperforming keyword-filtered LLM approaches (F1=0.703). Passive linguistic monitoring using DementiaBank data achieved a 72.67% F1-score for detecting mild cognitive impairment progression. Real-time face identification achieved 99.1% accuracy with sub-250ms latency. These results demonstrate the feasibility of a fully localized "memory prosthesis" that provides proactive semantic assistance while preserving patient privacy. The framework establishes a scalable foundation for integrating edge-based multimodal AI into dementia care and future EHR interoperability.

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

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

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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

2026

Word Count	Fair Category	Project Number
120	PS	6008

Title: A Graphene Oxide-Enhanced Biochar System for PFAS Filtration and Mineralization

Student Name(s): K. Addai-Boateng

Abstract:

Per- and Polyfluoroalkyl Substances (PFAS) are persistent "forever chemicals" found in drinking water, posing significant health risks including immune system disruption, thyroid disease, and certain cancers. This project investigates the use of biochar derived from local Connecticut hardwood and agricultural waste as a low-cost, sustainable method to remove PFAS from water. Biochar filters were prepared from hardwood chips, corn stalks, and nut shells, then tested for PFAS adsorption. Results show that hardwood biochar achieved the highest PFAS removal efficiency, demonstrating the potential for small-scale applications in homes, schools, or communities. This project highlights a practical approach for interim water treatment and safe chemical disposal at centralized facilities, offering an environmentally friendly solution to a growing public health problem.

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

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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

2026

Word Count	Fair Category	Project Number
176	PS	6009

Title: Conics Defined by Triangle Centers in Ceva Configurations

Student Name(s): B. Cha

Abstract:

Our research was motivated by the following two Euclidean geometry results:
Theorem 1 (Lamoen, 2000). The medians of a triangle divide it into six smaller triangles. The circumcenters of these triangles lie on a circle.
Theorem 2 (Bradley, 2007) The angle bisectors of a triangle divide it into six smaller triangles. The incenters of these triangles lie on an ellipse. Even though they involve only elementary geometric objects, these two results are relatively new.

It is therefore interesting to study the following problem:
Let Q be a point in the interior of a given triangle ABC. The cevian lines though Q divide ABC into six smaller triangles. For what locations of Q, are the centroids (incenters, circumcenters, orthocenters) of these triangles lying on the same conic?

We obtain a complete characterization of the locus of Q in each of these four cases.
Moreover, we prove a similar result when Q is the de Longchamps center of ABC; in this case we show that the 9-point centers of the six smaller triangles lie on a conic.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
258	PS	6011

Title: From Fumes to Fertilizer: A Dual-Stage Catalytic System Converting Livestock Methane into Carbonate for Sustainable Crop Growth

Student Name(s): A. Pal

Abstract:

Methane is a powerful short-term greenhouse gas driving short-term climate warming, primarily from manure storage and enteric fermentation of livestock in small to mid-sized farms, contributing to 37% of human-produced methane (USEPA). This project presents a solution that converts those gases into a fertilizer additive: calcium carbonate, using a dual-stage catalytic oxidation and carbon capture system. In the proposed design, methane is first oxidized into methanol and subsequently to carbon dioxide using metal oxide catalysts tested on affordability, safety, and efficiency. The resulting carbon dioxide is neutralized in an alkaline solution, calcium hydroxide, to form the calcium carbonate additive.

Initial development of the system included conceptual design, selection of catalysts based on available literature, and an at-home experiment testing the effects of sodium carbonate on radish plant growth. Sodium carbonate was used to model effects on plant growth to guide calcium carbonate applications. Results indicated that carbonate concentrations of 0.3g in its crystalline form promoted plant growth by 13.33% compared to the control plants and regulated pH to the ideal 6.5 range. UConn research involved testing at the Institute of Materials Science to evaluate efficiency and structure of D-block catalysts for the methanol to carbon dioxide reaction. Catalysts and mix-oxides were synthesized through sol-gel processing and tested using BET, BJH, SEM, and XRD testing to find pore size, surface area, morphology, and structure. That information revealed that manganese dioxide catalysts would result in the highest conversion yield. Estimated budgeting and energy analysis suggest the system could also profit farmers.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
243	PS	6012

Title: Developing a Bio-Hybrid Luminescent Solar Concentrator Using Carbon Quantum Dots, Natural Fluorophores, and Kaolin Powder for Enhanced Solar Energy Harvesting

Student Name(s): A. Shrivastav

Abstract:

Luminescent Solar Concentrators (LSCs) are transparent devices designed to improve solar cell efficiency by absorbing ultraviolet (UV) light and re-emitting it at visible wavelengths more effectively used by photovoltaic cells. This research investigates low-cost, bio-hybrid LSCs as a potential solution for transparent, building-integrated solar technologies. While many LSCs rely on expensive or toxic materials, there is a gap regarding the effectiveness of affordable, biologically derived alternatives. The aim of this study was to evaluate whether bio-hybrid materials could enhance solar cell output while maintaining optical transparency. Twenty-one epoxy slabs (10 × 10 × 0.5 cm) were fabricated across seven experimental groups, including a control, using carbon quantum dots (CQDs), chlorophyll, curcumin, and kaolin embedded in an epoxy matrix. Optical performance was measured using average visible transmittance (AVT), while electrical performance was assessed through current and maximum power output from edge-mounted solar cells. Statistical analysis was conducted using one-way ANOVA with Tukey HSD and Dunnett's post-hoc tests. Results showed that slabs containing CQDs and chlorophyll increased electrical power output by approximately 30% compared to the control, with minimal loss of transparency, indicating effective UV-to-visible downshifting. In contrast, curcumin- and kaolin-based slabs reduced performance due to increased light scattering and optical losses. These findings suggest that CQDs and chlorophyll are promising materials for low-cost, transparent photovoltaic applications. These results support the feasibility of scalable, eco-friendly LSCs for next-generation energy-efficient building design.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
254	PS	6014

Title: A Voice-Controlled Robotic Arm for Assisting Complex Surgical Tasks

Student Name(s): D. Maltese

Abstract:

In the U.S., there are over 250,000 annual deaths attributed to medical errors, with over 4,000 involving surgical accidents. While current robotic surgery has advanced precision in the operating room, nearly all current systems rely on a master-slave control system, requiring surgeons to manipulate the robot through a hand-operated console. As Augmented Reality (AR) is integrated into the operating room to enhance precision, it also increases a surgeon's cognitive load, especially when manually manipulating tools like an ultrasound probe, which is crucial for AR-guided procedures. To combat this, I developed a voice-controlled robotic arm to serve as an additional "hand," reducing multitasking while keeping a surgeon focused on the procedure. This device aims to aid surgeons by assisting with tasks that need to be completed, rather than replacing the surgeon's hands. The device was 3D modeled, machined in aluminum, and is driven by NEMA stepper motors coupled to harmonic drives for high torque and low backlash. In motion-control and stability tests, the robotic arm demonstrated accurate, repeatable motion with responsive, real-time voice activation. Clinical feedback at Weill Cornell Hospital has shown strong potential to improve ultrasound handling and similar precision-based tasks, with benefits in efficiency and concentration. Ongoing work aims to develop a claw, expand the task library, and implement the device across numerous surgical scenarios. By pairing AR with autonomous robotic manipulation, this system moves beyond traditional robotic surgery, creating a more intuitive assistant that offers a pathway to safer, more efficient, and cognitively lighter surgery.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
186	PS	6016

Title: Monte Carlo Simulation-Based Probability Model of Wildfire Spread on a Two-Dimensional Grid

Student Name(s): H. Lee

Abstract:

A probabilities mathematical model has been developed to investigate how wildfire spread across a two-dimensional grid. Specifically seeking to answer the research question as to how the expected burned area is influenced by the ignition probability and whether there is a critical threshold on the transition of fire to widespread, simulations were conducted using Python program, specifically with Numpy, to generate random ignition matrices, while applying probabilistic cell-to-cell spread rules to each grid. With the generated model, Monte Carlo trials were performed for 10,000 times for each value of ignition probability, estimating the mean burned area. Using Matplotlib, the results were visualized, indicating consistent phase-transition dynamics. With low ignition probabilities of less than 0.40, small and self-limiting fires were seen. With high ignition probabilities of greater than 0.60, fires turned out to frequently span a large portion of grid. A critical threshold was consistently calculated to be around 0.55 as the transition occurred. This research demonstrated that a simple stochastic model on a grid may produce complex wildfire emergent patterns through a mathematically grounded framework in an understanding of wildfire spread.

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

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
244	PS	6019

Title: Exploration of the Neuroprotective Potential of Moringa Oleifera

Student Name(s): R. Li

Abstract:

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by β-amyloid (Aβ) plaque accumulation, cholinergic dysfunction, and cognitive decline. This study evaluated the neuroprotective potential of Moringa oleifera leaf extract through phytochemical profiling, computational docking, ADMET analysis, and in vivo validation in a Drosophila AD model. Leaves were extracted using 70% ethanol and analyzed by HPLC–DAD at 280 nm.

Quercetin was identified as the dominant compound (55%) using an external calibration curve, while additional phenolics including gallic acid, catechin, and chlorogenic acid were reported as relative abundances based on retention behavior and UV spectra. Molecular docking using SwissDock (AutoDock Vina scoring) demonstrated favorable binding affinities of these compounds to β-secretase (BACE1) and acetylcholinesterase (AChE), suggesting potential inhibition of amyloid processing and cholinergic degradation. SwissADME analysis indicated acceptable drug-likeness, predicted gastrointestinal absorption, and low toxicity risk.

Functional effects were then assessed using a Drosophila melanogaster negative geotaxis (climbing) assay. Extract-treated flies showed dose-dependent improvement in locomotor performance, with 0.5 mg/mL producing the greatest effect (70.5% climbing versus 20.4% control). ATR-FTIR analysis of fly heads in the Amide I region (1600–1700 cm^{-1}) revealed reduced β-sheet content in treated groups, indicating decreased amyloid-like protein aggregation. These results demonstrate that Moringa oleifera contains bioactive phenolic compounds capable of modulating key AD molecular targets, reducing aggregation-associated β-sheet structure, and improving functional outcomes, supporting further investigation of this plant as a potential source of neuroprotective therapeutics.

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

2026

Word Count	Fair Category	Project Number
240	PS	6020

Title: DESIGNING A CIRCUIT TO CONTROL A 60 YEAR OLD CATHODE RAY TUBE

Student Name(s): O. Davis

Abstract:

Monochrome cathode ray tubes generate and accelerate an electron beam to achieve precise analog resolutions. However, millions of tubes are discarded as hazardous waste, posing environmental hazards, despite their potential for use in STEM education. My objective is to demonstrate the feasibility of controlling and driving an obsolete cathode ray tube, CRT, using modern low-cost electronics. A high-voltage step-up module and resistor divider chain generated the high voltages needed for the CRT's acceleration anode (800 V) and focus (110 V). The CRT's deflection plates were controlled using a DAC-driven inverting linear amplifier producing a 230 V output swing. The circuit was controlled by a Raspberry Pi executing vector-rendering algorithms that converted 2D coordinates into 12-bit DAC signals. In testing, the circuit generated and accelerated a stable beam, and the DAC-driven amplifiers produced and controlled CRT deflection in response to a square-wave input. Testing of the vector-rendering algorithm was limited by a high-voltage power supply failure; the control logic was verified using a digital simulation of the CRT. These results demonstrate that, given careful attention, legacy CRT technology can be safely and effectively controlled using off-the-shelf components, providing a foundation for further exploration for use in electron beam experiments.

- AI tools chat GPT and Grammarly were used to help to help refine and edit my abstract (and the writing on my poster, not sure where/how to cite that)

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
264	PS	6021

Title: Generation of A Uniform, Ultra-high Temperature, and Stable Plasma for Material Innovation

Student Name(s): E. Feng

Abstract:

Conventional synthesis methods face significant limitations when producing materials designed for use in ultra-high temperature environments required for real-world applications, such as furnace linings, spacecraft heat shields, hypersonic aircraft components, and nuclear reactor parts. Therefore, there is a crucial need to generate a stable, scalable, and innovative synthesis approach capable of operating at extreme temperatures and enable the manufacturing of novel materials beyond the reach of conventional techniques. Thermal plasmas can create ultra-high temperature, highly reactive, and non-equilibrium environments that are attractive for a wide range of materials synthesis and processing applications, making them a powerful method for extreme-temperature synthesis. However, limited plasma volume, instability, and non-uniformity constrain scalability for manufacturing bulk, high-temperature materials. The presented laboratory research demonstrates the generation of a uniform, stable, ultra-high temperature plasma (up to 8000K) at atmospheric pressure using a specially designed plasma set-up with a pair of carbon-fibre-tip-enhanced electrodes. The electrode tip contains a combination of a highly dense array of vertically oriented short carbon fibres alongside long carbon fibres that extend into the inter-electrode gap and form contact between the two electrodes. The long carbon fibres initiate the plasma formation through micro-spark discharge at a low breakdown voltage, while the densely packed short carbon fibres coalesce the initially-formed discharge into a volumetric, stable, ultra-high-temperature plasma. The generated plasma can be maintained about for 30 minutes or longer with a sustained, consistent power input, providing a stable platform for synthesizing materials under extreme-temperature conditions and for extreme-temperature applications.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
141	PS	6022

Title: Bioremediation of nitrates using chitin and chitin derivatives

Student Name(s): K. Thibeault

Abstract:

The purpose of this project was to test the efficacy of different forms of chitin to remediate nitrates. Chitin, with its positively charged amine groups, is a nitrogenous carbohydrate found in the shells of crustaceans and theoretically should attract the negative charges of the nitrates. A magnesium-doped chitin composite was also created to see if the magnesium would increase efficacy of the nitrate remediation. A standard solution of sodium nitrate was used for the source of nitrates. Water samples were passed through a chitin filter. UV-VIS spectorphotometry was used with a colorometric assay to determine concentrations when compared to a known standard curve. The chitin remediation removed approximately 41% of nitrates. The magnesium-doped chitin was less effective and only remediated approximately 19%. Chitin is a naturally occurring compound and may serve as a good candidate for remediation purposes.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
257	PS	6023

Title: Optimizing Fin Design for a Mars-Launched Rocket Using Modified OpenRocket Simulations

Student Name(s): A. Arvind

Abstract:

Future Mars missions, including sample-return efforts, require ascent rockets capable of launching reliably from the Martian surface and reaching sufficient altitude to continue into space. Mars presents a significantly different launch environment than Earth due to its lower gravity and much thinner atmosphere, which alters rocket stability and aerodynamic behavior. The purpose of this project was to investigate how rocket fin geometry affects stability and altitude performance under Martian conditions and to identify an optimal fin design that balances both requirements. The hypothesis was that a fin design optimized specifically for Mars would outperform designs adapted from Earth-based assumptions. To conduct this investigation, the open-source rocket simulation software OpenRocket was modified by the student to allow gravitational acceleration to be defined by the user, enabling accurate simulation under Martian gravity. A three-stage Mars ascent rocket was selected as a baseline configuration after preliminary staging analysis. Using this modified simulation environment, 56 different fin geometries—including rectangular, trapezoidal, swept, and elliptical planforms—were tested while holding all other variables constant. For each design, static stability margin, drag coefficient, and maximum apogee were recorded and analyzed.

The results showed that fin geometry has a significant impact on rocket performance. Six designs were eliminated due to insufficient stability. Among the remaining stable designs, those with higher drag coefficients consistently achieved lower apogees. A trapezoidal fin with an airfoil cross-section achieved the highest stable apogee of 12,846 meters while maintaining a stability margin of 1.31 calibers and a low drag coefficient. These results support Mars ascent.

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

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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

2026

Word Count	Fair Category	Project Number
246	PS	6026

Title: Development of a Hydrophobic and Oleophilic Sponge for Selective Oil Absorption

Student Name(s): A. Gupta

Abstract:

While oil spills are harmful to the environment, cleanup methods such as booms, in situ burning, and chemical dispersants impose further burdens upon local ecosystems. This study presents an environmentally safe, low-cost alternative by using a melamine sponge modified with a stearic acid coating, creating a hydrophobic surface.

To evaluate performance, the study established the Oil Selectivity Index (OSI), the ratio of oil absorbed compared to the total intake. Experimental results established an optimal coating concentration of 2.4 wt% stearic acid, which achieved an OSI of 0.840 and recovered approximately 35 times the weight of the sponge. The performance data followed a Gaussian distribution with a strong R2 value of 0.843. Lower concentrations resulted in an inconsistent coating, while excessive loading clogged the pores and trapped water within surface irregularities.

Furthermore, contact angle measurements revealed that surface hydrophobicity does not indicate internal absorption efficiency. While sponges made with lower concentrations of stearic acid maintained high water contact angles (120 degrees), higher concentrations transitioned to a Wenzel state.

Attempts to improve the project by replacing melamine with biodegradable cellulose were made. However, a treated cellulose sponge failed to achieve similar results (OSI of 0.488) likely due to its open structure, allowing absorption through capillary action regardless of the coating.

This solution is 91% more cost-effective than industrial standards, removing oil at only $0.19 per kilogram. These findings demonstrate that modifying sponges offers a scalable, non-toxic

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

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

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

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

☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
230	PS	6027

Title: Continual Learning with Elastic Weight Consolidation for House-Tree-Person (HTP) Test Frameworks

Student Name(s): R. An

Abstract:

Child mental health issues are often undetected due to children's limited ability to recognize or communicate their emotional states. The House-Tree-Person (HTP) test is a commonly used projective drawing assessment for identifying subconscious emotional and cognitive patterns in children, yet its clinical utility is constrained by high administration costs, subjectivity, and lack of standardized online versions. This paper presents a novel web-based HTP analysis framework that leverages object detection to automate and standardize interpretation. Processing HTP drawings with machine learning models poses several challenges. These drawings are grayscale, lacking detailed information, and exhibit high domain variance due to the diverse drawing skills of individuals across different ages. To address these challenges, this paper focuses on improving object detection performance for HTP drawings. We introduce a novel continual learning strategy. We introduce a continual learning strategy with Elastic Weight Consolidation (EWC) to prevent catastrophic forgetting across tasks of increasing difficulty, enabling the model to adapt from coarse- to fine-grained recognition progressively. This approach significantly enhances detection accuracy and spatial precision, achieving 94–99% classification accuracy and an average Intersection over Union (IoU) of 0.82–0.84 across HTP categories. A simple web-based visualization interface has been developed only to demonstrate the practical deployment of the trained detection model. This work underscores the importance of robust object detection as the foundation for future automated and interpretable psychological assessments.

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

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

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☐ vertebrate animals ☐ controlled substances

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
230	PS	6029

Title: A Multiscale Evolutionary Simulation and Machine Learning Framework to Predict Immunotherapy Failure from Tumor–Immune Interaction Dynamics

Student Name(s): S. Desiraju

Abstract:

Immune checkpoint inhibitors targeting PD-1/PD-L1 have transformed cancer therapy, yet most patients fail to respond or develop resistance. This failure is driven by tumor–immune dynamics, including $CD8^+$ T-cell exhaustion, immunosuppressive cell populations, and tumor heterogeneity. While single-cell RNA sequencing (scRNA-seq) captures these processes, predictive modeling is limited by small labeled cohorts and high overfitting risk. This study presents a biologically grounded, leakage-free machine learning framework for predicting immunotherapy response. A labeled cohort of 29 patients was used for training and evaluation, while an external cohort of 112 patients was used exclusively for feature discovery without outcome labels. Features included immune cell proportions, exhaustion and cytotoxicity scores, tumor proliferation, diversity metrics, and discovery-derived gene signatures. To address small-sample constraints, the pipeline used strict nested leave-one-out cross-validation with stability-driven feature selection. The final model achieved a nested LOOCV ROC-AUC of 0.667 (95% CI: 0.441–0.876) and a bootstrap AUC of 0.804 ± 0.099. Key predictors included proliferation, $CD8^+$ T-cell fraction, exhaustion signatures, regulatory T-cell abundance, and discovery-derived immune features. Unlike conventional approaches that risk overfitting, this framework integrates external biological data without violating training boundaries and prioritizes stability and interpretability. These results demonstrate that even with limited labeled data, combining biological insight with rigorous validation can yield consistent and clinically relevant predictions of immunotherapy response.

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

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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

2026

Word Count	Fair Category	Project Number
256	PS	6030

Title: GRIP: Novel Machine-Learning Interatomic Potential Architecture and Clebsch-Gordan Tensor Product Algorithm For Efficient and Accurate Materials Modeling

Student Name(s): R. Ma

Abstract:

Materials discovery depends heavily on reliable predictions of energies and forces from atomic structures. Machine-learning interatomic potentials (MLIPs) have become a leading approach, providing near ab initio energies and forces at much lower cost. However, state-of-the-art (SOTA) MLIPs remain difficult to run in practice because a dominant algorithm in MLIPs, the Clebsch-Gordan tensor product (CGTP), is computationally demanding in runtime, memory, access to expensive graphics processing units, and energy consumption. This work introduces GRIP (Gated Recurrent Interatomic Potential), a novel MLIP architecture, that attains near-SOTA accuracy while being much cheaper and faster to run. The derivation of a novel CGTP algorithm enables GRIP to reach 7.695 samples/s (2.5× faster than the SOTA model PET-OAM-XL) while using 6.3× less GPU energy, over 20× less GPU memory, and 12× lower GPU utilization. Additionally, GRIP enables simulations up to 13,000 atoms on a single NVIDIA A100, extending feasible system sizes by 8,000 atoms relative to the most efficient baseline. On a leading stability-classification benchmark of 215,488 structures, GRIP achieves an F1 score of 0.922, nearing the SOTA model (0.924), and demonstrates competitive generalization on an out-of-distribution catalyst modeling benchmark. Overall, GRIP improves the efficiency of large-scale materials screening, enables larger simulations, and expands access to ab initio quality modeling with lower computational and energy requirements. By reducing runtime, memory use, and GPU demand, GRIP helps mitigate environmental costs and lower practical barriers of deploying MLIPs, particularly in settings with limited access to high-performance computing resources.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
263	PS	6034

Title: Vision Transformer Versus Convolutional Neural Network Architecture in Exoplanet Transit Classification

Student Name(s): S. Diamond

Abstract:

Exoplanet discovery relies heavily on transit photometry, where periodic dips in stellar brightness reveal planetary orbits (Tolasa&Furi, 2025). While Convolutional Neural Networks (CNNs) are standard for automated light curve classification (Cuéllar,2022), Vision Transformers (ViTs) may outperform them by capturing long-range dependencies (Khan,2023). However, no direct comparison using identical datasets and preprocessing existed prior to this. This study compared the models to determine which achieved better performance and lower computational demand. Light curves from the Kepler mission trained both models. The CNN analyzed 1D detrended, phase-folded, and binned flux values; the ViT analyzed 2D recurrence plots of the same data; preprocessed identically (Choudhary,2025; Shallue,2018). It was hypothesized that the ViT would be higher in performance due to its global attention mechanism, requiring greater computational resources (Choudhary2025; Khan,2023). Following training, test data was used to determine model performance and computational demand. The CNN had precision, recall, and F1 score of 91.92%, 84.68%, and 88.15%, respectively, while the ViT had 96.04%, 92.98%, and 94.49%, respectively, with a McNemar's p-value of 7.08X10^-10 showing an extremely statistically significant difference between the models. The CNN and ViT used approximately 2.4X10^12 and 1.3X10^14 FLOPS, respectively, with similar runtimes (Floating-PointOperationsperSecond,2025). This would cost NASA approximately 0.656 and 36.4 cents to sort the 940 testing light curves used in this study, both extremely low costs (SupercomputingFacility SavesEnergyCostsforNASA| GDIT, n.d.). These results demonstrate that ViTs are superior to CNNs for transit classification, even with higher computational demand, and should be used for future missions detecting candidates, advancing planetary science.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
170	PS	6037

Title: Exploring Adaptive Learning in Autonomous Vehicles:

A CNN-Based Proof of Concept for Self-Autonomous Vehicle Intelligence (SAVI)

Student Name(s): Y. Chandrasekaran

Abstract:

Autonomous driving systems continue to face challenges in adapting to unfamiliar conditions. A 2020 AAA study found that Level 2 driver-assistance systems experienced issues about every eight miles during real-world testing, showing the need for adaptive vehicle intelligence. This study introduces SAVI (Self-Autonomous Vehicle Intelligence), a proof-of-concept framework for future adaptive learning in autonomous vehicles. To evaluate SAVI's offline learning phase, I trained a lightweight convolutional neural network (CNN) on the CIFAR-10 dataset, which served as a simplified stand-in for driving-related images. Three experimental configurations were tested to compare optimizer choice and training duration using training accuracy, validation accuracy, and RMSE value. The best-performing model used the Adam optimizer for 10 epochs, achieving 80.9% training accuracy, 70.4% validation accuracy, and the lowest RMSE value of 2.31. Although continual learning with new real-world driving data was not implemented, the results show that offline CNN training can serve as a proof of concept and foundation for future adaptive systems such as SAVI.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
256	PS	6038

Title: Design and Application of Gamified Health Tools: From Population-Level Habit Formation to Clinical Evaluation in Traumatic Brain Injury

Student Name(s): V. Scutari

Abstract:

In the United States, around 90% of the nation's $4.9 trillion in annual healthcare spending is linked to largely preventable chronic conditions such as obesity, type 2 diabetes, and cardiovascular diseases, according to the Centers for Disease Control. At the same time, traumatic brain injuries (TBIs) affect roughly one million Americans each year and leave an estimated 5.3 million living with long-term disability. These challenges raise a central question in modern healthcare: how can systems promote sustained preventive health while also improving care when serious injury occurs? This paper examines gamification as a strategy to address both challenges through two interventions. HealthHero, a gamified health-monitoring application, reframes preventative behaviors, such as exercise and sleep, into challenges and upgrades designed to promote long-term consistency and healthy habit formation in the general population. In a five-month pilot study with twenty-six adult participants, consistent app use was associated with upward trends in average sleep duration, step count, and active calories burned. Users identified progress visualization and upgrade systems as the most motivating features, suggesting that gamified feedback supported sustained engagement. The second tool, Comprehensive Assessment for Executive Dysfunction (CAED), is a tablet-based serious game that embeds diagnostic tasks in interactive scenarios designed to mimic real-world tasks in order to improve patient engagement and enhance the accuracy of executive function assessment in patients with TBIs. Together, these tools illustrate how gamified health interventions can bridge prevention and clinical care, offering scalable, engaging, and patient-centered solutions to two of healthcare's most pressing problems.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
251	PS	6040

Title: Arduino-Based Active Stabilization System for Model Rockets Using IMU Feedback and Servo-Driven Fins

Student Name(s): A. Gomez

Abstract:

Stabilization systems are crucial for hobby rockets to maintain stable, vertical flight during powered ascent. A rocket's stability during flight directly determines whether the launch succeeds. This project developed an active stabilization system to correct deviations from vertical flight using servo-controlled fins and an inertial measurement unit. Two major procedures were used. The first consisted of ground testing the sensor unit and servos before flight to make sure the code worked properly and the fins responded correctly to simulated stability and direction deviations. This testing proved the control loop worked. The MPU6050 inertial measurement unit detected orientation changes, the Arduino processed the data through a Kalman filter to reduce sensor noise, and the servos adjusted fin positions proportionally. The second procedure was the most important one, and it involved flying the rocket with the integrated stabilization system. Before launch, the Arduino calibrated the MPU6050 gyroscope to establish accurate baseline readings. During flight, the system immediately compensated for factors that pushed the rocket off its vertical path, including wind gusts and thrust imbalances. The rocket was successfully retrieved using a parachute recovery system. Slow-motion footage captured during launch was analyzed to evaluate system performance beyond the initial visual confirmation that the rocket remained stable and the system actively corrected deviations. This project successfully demonstrated that active fin stabilization can maintain vertical trajectory throughout powered flight. Future extensions could involve roll-control systems using the same framework, or additional sensors and a camera for data and video collection at high altitudes.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
231	PS	6044

Title: Developing a Methodology to Predict Flash Flooding in Southwestern Connecticut Using Historic Flood Events and Weather Data

Student Name(s): O. Rohrbasser

Abstract:

Increases in extreme precipitation and heavy storms cause sudden flash flooding, damaging communities and threatening their residents' safety. While technology in flood prediction can drastically mitigate the threat to human life, there is currently a lack of simple, widely accessible flood predicting models. This study determined if historical weather and flash flood data could be used to predict flooding for a location to a high degree of accuracy. A methodology was developed that performed logistic regression on variations of a ten year dataset in Fairfield County, CT, from 2015 to 2025. A regression performed on a dataset containing 100 randomly sampled non-flood days plus all flood events in a ten year period accurately predicted 62.32% of flood days on average. It was also determined that larger background datasets, interaction variables, and multi-day precipitation sums did not improve flood prediction accuracy. These results were validated by testing flood and non-flood days from a dataset outside of the ten year study period. There were few false positives and negatives that occurred on days where precipitation totals would be expected to yield the opposite result. The success of this sampling method and consistency of the outliers indicates that this model is a valid form of flood forecasting. Future work that employs a dataset with a higher flood concentration in close proximity to measured background data can further improve this model's accuracy.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
236	PS	6047

Title: Applying Causal Inference Methodologies to a Large-scale Publicly Available Dataset to Assess Causality Between Nutrient Deficiencies and ADHD Diagnoses

Student Name(s): S. Javeri

Abstract:

ADHD is a common neurodevelopmental disorder without well understood causes. Published studies have shown correlations between nutrient deficiencies and ADHD diagnoses. However, a causal relationship between these variables has yet to be established. This project aimed to apply causal inference methodologies to publicly available data from the National Health and Nutrition Examination Survey (NHANES), a cross-sectional national health survey, to investigate the likelihood of a causal relationship between nutrient deficiencies and ADHD diagnoses. This research is important because a result suggesting a causal relationship could impact future ADHD treatment. NHANES is conducted by the CDC in 2-year cycles, with approximately 10,000 respondents each cycle. The dataset contains laboratory tests for Vitamin D & E (Exposures) as well as ADHD diagnoses (Outcome) for certain cycles. Statistical tools such as propensity score matching and logistic regression were utilized to measure the total causal effect of nutrient deficiencies on ADHD. Analysis of the data found 30% higher odds of ADHD amongst those with Vitamin E deficiency (OR = 1.33; 95% CI 0.96-1.83; p = 0.083). Vitamin D analysis indicated the odds of ADHD was, surprisingly, 35% lower amongst those who were deficient (OR = 0.65; 95% CI 0.35-1.19; p = 0.15). The Vitamin E findings fell just short of the threshold for statistical significance but suggested that there is possibly some causal relationship between deficiency and ADHD. The Vitamin D findings failed to replicate prior studies demonstrating correlation between deficiency and ADHD.

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

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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

2026

Word Count	Fair Category	Project Number
254	PS	6048

Title: Developing a Fast Response Aerosol Optical Depth Monitor for Continuous Information on Ambient Particulate Matter

Student Name(s): A. Shrivastav

Abstract:

Fine particulate matter (PM) poses serious health and environmental risks. Because PM scatters and absorbs light, Aerosol Optical Depth (AOD), which measures light scattering and absorption, can estimate PM levels. However, current AOD sensors are limited by dependence on sunlight and slow response times, highlighting the need for a faster sensor that can provide continuous, real-time PM data. The purpose of this project was to design and develop a rapid-response AOD monitor for real-time and continuous monitoring of ambient particulate matter. The original sensor design was altered using Tinkercad to reduce the dimensions of the main aperture (in the center of the sensor) and sampling tube. A 3D printer printed the new prototype, which was used along with a LUX sensor at its bottom to measure the luminosity change due to the presence of aerosols from incense sticks that were pulled in by an air pump attached to the side of the sensor, and an LED light at its top. Two prototypes were tested, and AOD values were calculated after experimentation. The data for both prototypes were statistically significant (r-squared > .95); however, neither met the 20-minute stabilization criterion, and percent luminance changes of under 5% indicated insufficient responsiveness to increased aerosol concentrations. Chamber size, uneven aerosol distribution, and sensor limitations likely restricted rapid stabilization and accurate measurements. The findings provide a clearer understanding of how chamber design and particle distribution influence stabilization time and accuracy, establishing a foundation for faster real-time air quality monitoring to improve public awareness.

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

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

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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

2026

Word Count	Fair Category	Project Number
266	PS	6051

Title: Designing and Manufacturing a Wing Design Optimized for High-Endurance Mars Flight

Student Name(s): T. Singh

Abstract:

Mars exploration represents a critical step in long-term human space advancements and advancing the knowledge of planetary science. It's limited by the capabilities of current imaging vehicles. Rovers provide high-resolution images but cover small areas, while satellites cover large areas with low-resolution images. Achieving fixed-wing flight on Mars could bridge this gap. Therefore, my project is designing a wing shape that is capable of sustained flight.

Achieving winged flight on Mars is a challenge due to the significant decrease in air density (.015kg/m3) compared to Earth air density (1.225 kg/m3), which leads to a decrease in aerodynamic performance (83.2%). In order to overcome this engineering challenge, a wing design optimized for a high lift-to-drag ratio was modeled using a computer-aided design (CAD) software. The shape was selected to maximize lift while minimizing drag under low-density conditions. The experimental lift data was then compared with the simulated data and resulted in a 20% margin The simulation was calibrated using wind tunnel data to ensure correct aerodynamic predictions before simulating the wing in a Martian atmosphere. The formation of laminar separation bubbles still remains a problem in aerodynamic performance. The implementation of winglets was not tested.

Under Martian conditions (ρ=.015kg/m3, Re $\approx$ 2.05*105). The optimized wing achieved maximum lift-to-drag ratio of 6.9 and improved L/D ratio by 17% over the NACA 2412 control airfoil in subsonic flow. These results demonstrate aerodynamic feasibility for sustained flight in low-density CO2 conditions. The improved aerodynamic efficiency allows for high-endurance flight, allowing broader surface mapping.

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

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

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

2026

Word Count	Fair Category	Project Number
234	PS	6053

Title: Evaluating the Effectiveness of Agricultural Waste-Derived Biochars Embedded in Sodium Alginate Hydrogel Beads for Mitigating Copper Ion Toxicity

Student Name(s): A. Bhuyan

Abstract:

Heavy metal pollution poses a significant threat to aquatic ecosystems, with contaminants like copper (II) ions entering water systems through industrial and agricultural runoff. Conventional remediation methods that target copper contamination are expensive, generate toxic chemical sludge, and often fail to address the ecological impacts of pollution. This study evaluates the effectiveness of sodium alginate-chitosan hydrogel beads infused with biochars derived from coconut shell, orange peel, and spent coffee grounds in reducing the biological toxicity of aqueous copper ions. Biochars were produced via controlled pyrolysis of agricultural waste materials and subsequently incorporated into ionically cross-linked hydrogel beads. Hydrogel-biochar composites were characterized using scanning electron microscopy (SEM) to assess porosity and surface morphology, and their copper remediation capabilities were measured using A. fischeri bioluminescence assays and spectrophotometric quantification of residual copper. The mean gray value of bacterial light emission was quantified from DSLR photographs and used to calculate bioluminescence inhibition. Results showed that coconut shell hydrogels were most effective, reducing copper concentration by 93.8% to 0.31 ppm and producing only 6.8% inhibition of bacterial luminescence. Pearson correlation analysis revealed a strong negative correlation ($r \approx -0.98$) between residual copper concentration and bioluminescence, confirming that copper removal corresponded directly with bacterial protection. These findings demonstrate that biochar-containing hydrogels, particularly those made from coconut shell and coffee grounds, are highly effective at mitigating copper toxicity and highlight their potential for accessible water remediation strategies.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
253	PS	6054

Title: Assessing the Effectiveness and Performance of Adaptive Authentication in Isolation Against Volumetric DDoS Attacks

Student Name(s): C. Alvarado

Abstract:

A distributed denial of service (DDoS) attack is a cyberattack where a malicious actor generates large volumes of network traffic that slow vital processes, such as login pages. Although adaptive authentication has been shown to improve security, modern implementations often rely on transfer learning and machine-learning models trained on historical datasets, which can be costly and resource-intensive due to AI training. This study evaluates the standalone effectiveness of a rule-based adaptive authentication system against volumetric DDoS attacks by identifying behavioral metrics—IP addresses, location patterns, device and browser information, login speed, and request frequency—that distinguish bots from human users. A simulated login environment was constructed in Python, with DDoS behaviors generated using Locust, and human behavioral data sets from Freemen et al. were used to model legitimate traffic. Three trials were conducted: Trial 1 collected baseline traffic during a simulated DDoS attack without adaptive authentication; Trial 2 introduced dynamic risk scores; and Trial 3 refined parameters to balance detection accuracy and accessibility. Results showed that Trial 1 denied only 2.48% of bot requests despite artificial traffic, demonstrating limited protection. Trial 2 increased bot denials to 8.84% while raising human-user denials to 18.64%, indicating conflicts between security and usability. Trial 3 achieved 97.31% bot denials, showing improvement in attack mitigation, though stricter thresholds increased human-user denials to 50.41%. Overall, findings suggest that dynamic risk scoring based on behavioral metrics can strengthen DDoS defense without costly machine-learning systems, but refinement is needed to maintain accessibility for legitimate users.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
233	PS	6056

Title: Development of a Multi-Axis Adaptive Inertia Regulation Exoskeleton System: A Counter-Rotational Gyroframe for Stabilization and Energy Efficiency

Student Name(s): J. Lin

Abstract:

Electromechanical systems often face instability moving through their motors, and typical stabilization methods include IMU-based PID. However, this method requires continuous motor actuation, causing inefficient use of energy and mechanical wear. This project will focus on the design and validation of a compact multi-axis adaptive inertia regulation system where a counter-rotation dual-flywheels gyroframe will leverage angular momentum to provide a rapid, but energy efficient stabilization method. The main components include two high speed DC flywheels, Arduino Nano Every, a BNO055 inertial measurement unit, a DRV8833, and an INA219 current sensor. Unlike motor-driven stabilization, the gyroscopic torque is generated through angular momentum redirection, reducing the need for constant acceleration once the spin-up occurred. The usage of a closed-PID loop primarily controls the motor speed and direction, while gyroscopic torques are controlled by inertial dynamics. Testing of the stabilizer through tilt disturbance demonstrated bidirectional stabilization and corrective overshoot. The system also had a settling time of 0.25 seconds. Energy measurements, from the 5V system, revealed negligible idle power (7.5mW±0.8), low average consumption (415mW±3.2), and a peak usage at 500mW±4.7 (± represents Standard Deviation with over 10 trials). This confirms a high torque to energy efficiency. These results support that counter rotation gyroscopic regulation can reduce actuator workload while maintaining responsive multi-axis stabilization. The designs provide a scalable and energy efficient alternative for compact electromechanical applications.

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

2026

Word Count	Fair Category	Project Number
240	PS	6061

Title: DOTBot: Diffusion-Aligned Chain-of-Thought Bipedal Humanoid Robot for Interpretable Real-Time Autonomous Navigation, Hazard Mitigation, and Recovery in High-Risk Built Environments

Student Name(s): K. Srikumar

Abstract:

Autonomous disaster response robots rely on dense neural networks that compress sensor input into high dimensional states and output actions through opaque weights. While effective, these systems provide no interpretable causal trace, preventing operators from verifying safety in real time. This becomes critical in earthquake rubble, smoke filled corridors, and unstable structures. We hypothesize that aligning diffusion based visual perception with structured Chain of Thought reasoning improves both interpretability and action performance in autonomous robots. We present DOTBot, a bipedal humanoid robot that integrates diffusion vision with a formally grounded reasoning architecture. The core contribution is a mutual information alignment objective that links each reasoning step to the diffusion latent state during denoising, creating a traceable path from pixel observations to executable motor actions. When mutual information between latent visual states and reasoning steps is maximized, belief dynamics form a contraction mapping, and the Markov property holds over reasoning tokens, the resulting policy is reward optimal. DOTBot operates on a 950 dollar bipedal platform with torque stratified actuation, distributed microcontrollers, moisture resistant wiring, and a top mounted wide field camera designed for debris filled spaces. DOTBot was evaluated on aCOTion4000 (4,000 video clips with stepwise supervision), achieving 30.42 dB PSNR (+2.54 dB over the strongest baseline), 81.7% step accuracy (+8.2 points), and 87.9% frame action accuracy. All gains are statistically significant. These results demonstrate that interpretability and real world autonomous deployment can be achieved simultaneously within a unified theoretical and hardware framework.

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

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

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☐ vertebrate animals ☐ controlled substances

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

☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
220	PS	6062

Title: The Implementation of Microreactors and Hybrid Electric Rock Trucks into the Transportation Phase of Mining to Eliminate Diesel Rock Truck CO_2 Emissions

Student Name(s): C. Anderson

Abstract:

The mining industry is widely recognized as highly environmentally "dirty," particularly with respect to overall emissions, especially Carbon Dioxide (CO2. The use of internal combustion engines (ICEs) and diesel fuel has been the primary source of these emissions, which are a major cause of climate change. The engineering goal of hybrid electric rock trucks and micro nuclear reactors is to enable a new framework to achieve a 30% reduction in emissions. This study developed road designs for an existing mine using Google Maps and assessed differences in CO2 emissions between ICE- and EV-powered hybrid rock trucks. This simulation was designed to analyze the CO2-per-ton value for each tested variable, using a fixed value for each variable. After these frameworks were employed, it was found that an EV framework produces 2.1 times less CO2 than its ICE counterpart. Plans are to apply this framework to additional mines to assess how different landscapes may affect results. Despite the overwhelming success of this experiment, it is not certain that the same reductions will be observed across all frameworks, given differences in road gradient, transport needs, and travel factors. There is also a plan to investigate larger power sources, such as Small Modular Reactors, to facilitate on-site processing and refining and further reduce CO2 emissions throughout a material's life cycle.

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

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
142	PS	6065

Title: The Effect of Polarizing Sunglasses on Road Safety as the Sun Angle Changes

Student Name(s): B. Heusser

Abstract:

This project investigated how glare changes with the sun's angle in different seasons and how different sunglasses reduce this. For the experiment, a toy car with a light meter above the steering wheel was placed 50 cm from a heat lamp which simulated winter at a 25° angle to the car, spring/fall at a 45° angle, and summer at a 65° angle. The glare intensity was measured without sunglasses, with regular sunglasses, and with polarizing sunglasses. Results showed that glare was highest during winter, with readings around 750 lux without sunglasses, and lowest during the summer at around 175 lux. Both sunglasses reduced glare, however with polarizing sunglasses reducing it slightly more. This data shows that low sun angles, like in the winter, can create a much stronger glare, while wearing sunglasses, specifically polarized lenses will help reduce it the most.

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

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

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☐ vertebrate animals ☐ controlled substances

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
234	PS	6066

Title: PREDICTING MOTION OUTCOMES IN CIVIL LITIGATION CASES

Student Name(s): A. Sohail

Abstract:

Lawyers make many predictions in court cases based upon facts available to them at that time; however, these predictions tend to be biased and not well calibrated. Thus, many machine learning models have been used to make predictions about judicial decisions. These papers, however, have either failed to use categorical variables, that is administrative data (like court location, attorney ID, etc.), or employed information-poor features (like One-hot encoding). Moreover, previous works tend to use data not available at the time the judicial decision would have been made. The purpose of this research is to improve upon the performance of previous research by using data available at the time that the motions were filed and employ the help of tabular models which preserves high-dimensionality of categorical variables. This study involved training two tabular models, and unsupervised one and a supervised one, to produce embeddings from raw administrative data which was be used to train classic classifiers and the results were compared with the same classifiers trained on the raw data. Classifiers trained on the embeddings produced by the supervised tabular model had greater accuracy than classifiers trained on either raw data or the embeddings produced by unsupervised tabular models. This research depicts capabilities embeddings produced by supervised tabular models. More research is needed to see the extent to which these embeddings might improve the accuracy of judicial decision prediction via machine learning.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
190	PS	6068

Title: Statistical Analyses of Capital Markets to Investigate Correlations between different Mega Cap Equities, Industry Sectors, and Global Indices

Student Name(s): S. Ukidwe

Abstract:

The stock market is a complex system that reflects the constantly moving interaction between macroeconomic forces, company performance, and broader societal trends, resulting in the constant adjustment in value of public companies. Countless prior attempts to model market behavior have had limited success due to the unpredictability associated with human behavior. This project seeks to find both intuitive and less obvious relationships by analyzing correlation. To achieve this, I developed an algorithm that, using historical price data through the NYSE, analyzes correlations between individual stocks, country markets, and sectors, may result in a quantitative correlation constant. By putting up to 30 symbols simultaneously, the program computes the statistical correlations over customizable time intervals, enabling sophisticated comparison across every equity represented in the NYSE. The resulting correlation table allows for the identification of significant positive and negative correlations between pairs of securities. While not providing a full-prediction model for the market, this offers promise in portfolio construction and risk management. Specifically, it enhances various strategies, such as diversification, pair trading, and event driven trading, highlighting how each relationship can create opportunities whether macroeconomic or microeconomic before they become widely known.

Technical Disciplines Selected by the Student (Listed in order of relevance to the project) MA CS 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
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
265	PS	6070

Title: A Novel Coordination Rehabilitation System for Post-Stroke Motor Recovery Based on Equestrian Virtual Reality

Student Name(s): R. Xue

Abstract:

Stroke is a leading global noncommunicable disease with a rising incidence, causing severe motor coordination impairments and imposing heavy burdens on individuals, families and society. Traditional post-stroke rehabilitation methods suffer from subjective manual assessment, labor-intensive operation, and overemphasis on isolated muscle group training, which fails to meet the trunk-limb coordination demands of daily living activities and lacks real-time quantitative feedback and immersive training experience. To address these issues, this study develops a novel coordination rehabilitation system based on equestrian virtual reality (VR). Inspired by equestrian galloping movements and the principles of the Test of Gross Motor Development (TGMD), the system integrates 3D-printed wearable sensors (a whip and a belt embedded with gyroscopes and a pulse oximeter), Arduino-based real-time acquisition of motion and vital sign data, and a Unity-built immersive first-person equestrian VR simulation. A quantitative evaluation framework is constructed by adapting and integrating three classic clinical scales: Fugl-Meyer Assessment (FMA), Berg Balance Scale (BBS) and Trunk Impairment Scale (TIS), to assess trunk-limb coordination performance. A pre-post intervention experiment was conducted with a designed testing protocol, and kinematic indicators including movement smoothness and stability were measured to analyse the system's performance in dynamic data capture, trunk-limb synergy quantification and standardised coordination assessment. The system realises real-time capture and quantitative analysis of trunk-limb synergy under dynamic conditions, and builds a structured training and assessment process that combines virtual reality immersion with clinical rehabilitation criteria, which is expected to make up for the disconnection between traditional motor recovery training and daily functional practice.

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

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
247	PS	6071

Title: Effect of Spent Coffee Ground (SCG) Concentration on the Tensile Strength of Mycelium-Based Leather Composites Incorporating SCG

Student Name(s): E. Chung

Abstract:

Mycelium leather is a sustainable alternative to conventional and synthetic leather; however, its mechanical capabilities are constrained for scalable applications. This study uses a bio-composite mechanics paradigm to explain the observed relationship between the concentration of spent coffee grounds (SCG) and the tensile strength of mycelium-based leather. To begin, Pleurotus ostreatus (oyster mushroom) was cultivated on a hardwood sawdust substrate supplemented with 0 g, 50 g, 75 g, and 100 g of SCG per growth batch. It is hypothesized that SCG acts as a lignocellulosic particulate filler within the chitin-β-glucan mycelium matrix, and that tensile strength follows an inverted-U response to filler concentration: moderate addition reinforces the network via void filling and stress transfer, while excess addition triggers filler agglomeration, interfacial debonding, and disruption of hyphal network continuity. This hypothesis was supported by tensile testing (n = 3; mean ± SD), which showed that the 50 g SCG group had the highest mean tensile strength (0.27 ± 0.09 MPa), a 5.4-fold increase relative to the control. In contrast, higher SCG concentrations decreased tensile strength, with the 75 g and 100 g groups measuring 0.19 ± 0.17 MPa and 0.16 ± 0.15 MPa, respectively. These findings highlight the significance of microstructural interactions in bio-fabricated materials and determine the ideal filler threshold for optimizing mechanical performance in mycelium-based composites. Furthermore, this approach presents a scalable pathway for valorizing agricultural waste streams, with the potential to significantly reduce landfill and carbon emissions associated with traditional leather production.

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

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

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☐ vertebrate animals ☐ controlled substances

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
254	PS	6072

Title: Predicting Exoplanet Transit Detectability: A Python-Based Signal-to-Noise Model

Student Name(s): M. Jakubowsky

Abstract:

With an estimated 300 million Earth-like exoplanets in the observable universe, many potentially capable of supporting life, the study of exoplanets has become a pressing scientific priority. However, despite this scientific relevance, exoplanet detection remains largely inaccessible to nonprofessional astronomers. Existing tools require advanced expertise, and few provide practical, system-specific predictions. The aim of this research was to develop a user-friendly tool that enables nonprofessional astronomers to detect and study transiting exoplanets, expanding participation in exoplanet research. A Python model was created to predict the minimum detectable transit depth of an exoplanet for any given telescope and camera system by calculating the signal-to-noise ratio (S/N) for stars of different magnitudes and converting it into a corresponding detection limit. The model also estimates when an image will saturate based on stellar brightness and exposure settings, helping observers optimize their data collection. Model predictions were validated using data from the Barnes-Bristow Observatory in Simsbury, CT, and the John J. McCarthy Observatory in New Milford, CT. The S/Ns of hundreds of stars were measured and converted into minimum detectable transit depths. The model's outputs and experimental data differed by 0.97 parts-per-thousand (ppt), demonstrating excellent predictive accuracy. The model was successfully used to detect the exoplanet HD 189733b using instruments that had never previously been used for research purposes. Its precision and accessibility demonstrate its promise as a practical tool for small-telescope observatories and citizen scientists, with further refinement expected to enhance its accuracy and scientific impact.

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

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

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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

2026

Word Count	Fair Category	Project Number
213	PS	6076

Title: Trash to Treasure

Student Name(s): K. Earley

Abstract:

This project focused on the issue of landfill pollution and aimed to reduce pollution by educating students about the importance of properly recycling in order to protect our ecosystems. Trash to Treasure utilized education through a lesson created that informs students on the dangers of landfill pollution on the environment and how they can help even at their age, and included methods to minimize their own waste in addition to explaining why when we throw something out wrong, it can hurt our local environments. Paired with the lesson was a small art project where students brought in paper towel rolls to turn into butterflies, bees, or ladybugs as a way to reuse materials commonly used in the classroom and at home. The materials used were weighed and then multiplied per student participating which was 15, and the class that completed the project reused a total of 11.73 pounds of trash and was able to create their own bugs while learning ways to reuse waste. With combining recycling based habits to reduce the impact of real world issues with their own, small impacts, this project aimed to use education as a tool in which students should take a general lesson with them on how to make their own differences in environments harmed by landfills.

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

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

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☐ vertebrate animals ☐ controlled substances

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
172	PS	6078

Title: Determining the efficacy of bubble and merge sort algorithms

Student Name(s): A. Khan

Abstract:

The purpose of this project was to examine and compare the efficiency of an algorithm-based bubble sort and merge sort. Bubble sort is a basic comparison based sorting algorithm that repeatedly goes through a list, compares adjacent elements and swaps them if they are out of order.This process continues until the entire list is sorted. The complexity for bubble sort is O (n^2). Merge sort is an efficient sorting algorithm that uses a dividing system. It works by splitting a list into smaller parts, sorting those parts and then merging them back together in the correct order. Merge sort has a time complexity of O(n log n). The code used was generated using AI and sorts were tested using an exponential function of random numbers. Results were graphed and the intersection of regressions was determined. Bubble sorts were more efficient with smaller sample sizes and merge sorts were more effective when sample sizes were above 2000. Choosing a sort strategy is important to reduce overall power consumption for computational tasks.

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

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
252	PS	6079

Title: OPTIMIZATION AND PERFORMANCE EVALUATION OF SMA-BASED COMPLIANT MECHANISM DAMPERS FOR SEISMIC APPLICATIONS IN PENDULUM TUNED MASS DAMPERS

Student Name(s): D. Aguilar

Abstract:

Tuned Mass Dampers (TMDs) are widely used in high rise structures to mitigate seismic induced vibrations, but most rely on hydraulic dampers that introduce mechanical complexity, maintenance requirements, and potential failure modes associated with fluids, seals, and moving parts. This research investigates a solid-state alternative by using a single-part, monolithic Nitinol-based compliant mechanism to replicate the functional role and form factor of a hydraulic damper while exploiting intrinsic nonlinear damping behavior. A parabolic compliant flexure was modeled using finite element analysis to simulate compressive motion similar to a hydraulic piston within a TMD. Because superelastic Nitinol exhibits phase-dependent mechanical behavior, representative effective elastic moduli were assigned for austenite, transformation, and martensite regimes rather than assuming a constant modulus. Equivalent viscous damping ratios were calculated using an energy-based method across increasing displacement amplitudes corresponding to service-level, design-level, and extreme seismic motion. Results demonstrate notable amplitude dependent nonlinear damping. At small displacements, the mechanism remains stiff with minimal damping, while at moderate displacement coinciding with phase transformation, the damping ratio peaks at approximately 8.5%, within the optimal range reported for tuned mass damper applications. At larger displacements, damping decreases while flexure stiffness increases, providing a natural limiting response. This behavior mirrors desirable performance trends observed in high performance hydraulic dampers, while eliminating fluid based components. These findings suggest that monolithic Nitinol compliant mechanisms offer a viable, scalable, and tunable pathway toward simplified, solid-state tuned mass damper systems capable of adaptive vibration control in real world structures.

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

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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

2026

Word Count	Fair Category	Project Number
239	PS	6080

Title: Multimodal Dog Identification Using Facial and Nose Print Biometrics

Student Name(s): Y. Wang

Abstract:

Over 10 million pets go missing each year in the US. Existing pet identification systems require either a physical device or the pet owner themselves, and are often unreliable and cumbersome. In this work, we propose a noninvasive, software-based dog identification system that uses facial images that include the nose region as a combined biometric. To the best of our knowledge, this work is one of the first to apply a two-stage deep learning and local feature matching pipeline for pet identification.

A base collection of over 13,000 dog face images was used to develop the original model. A YOLO11 detector locates a dog face region with the nose region included. A ResNet50-based encoder then extracts a feature vector for the encoded face, which is stored in a vector library. For identification, the top five matches are selected using cosine similarity above a confidence threshold, and a SIFT-based local feature matching step is applied to these top candidates to confirm or reject matches.

On a hard negative test set of 27 dogs with 135 queries, the system rejected 39 low confidence queries and among the remaining 96 achieved 96.9% accuracy (93/96) with zero false positives, compared to the baseline March 2025 model accuracy of 88.9% (120/135). These results demonstrate that this two-stage matching algorithm has the potential to be used as part of workflows for animal shelters, law enforcement, and reunions with pet owners.

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

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

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☒ vertebrate animals ☐ controlled substances

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

☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
246	PS	6083

Title: A Sustainable Treatment For Heavy Metal Pollution: Adsorption and Desorption of Ni(II) Ions In Water Using DNA-Wrapped Carbon Nanotubes

Student Name(s): B. Reinhoefer Ribeiro

Abstract:

As of 2024, one in four people globally lack access to safe drinking water. In 2021, the United Nations (UN) reported that over 40% of 75,000 bodies of water in 89 countries were severely polluted. Developing efficient, sustainable, and cost-effective wastewater treatment solutions is therefore imperative. Adsorption—the physical or chemical adherence of pollutants onto a larger surface—has gained attention for its sustainability, particularly because of desorption, a process in which pollutants detach from adsorbent surfaces for reuse. Carbon nanotubes (CNTs), pure carbon nanomaterials, can function as ad/desorbents but face limitations such as insolubility and aggregation, which reduce adsorption efficiency. DNA-wrapped CNTs (DNA-CNTs), however, are more soluble and aggregate less, making them promising alternatives. In this study, DNA-CNTs were tested as viable ad/desorbents of Ni(II) metal in water. A batch adsorption experiment using varying DNA-CNT dosages over time demonstrated effective adsorption. Desorption was then attempted through sonication (ultrasound treatment) and heat application. Heat application effectively triggered desorption of Ni(II) ions from DNA-CNT surfaces, supporting the hypothesis, whereas ultrasound treatment unexpectedly enhanced adsorption. By significantly improving adsorption efficiency, ultrasound treatment offers a new perspective on adsorption scalability. Additionally, heat-induced desorption permits exploration of filtration methods for DNA-CNTs and reuse of the same DNA-CNTs for repeated ad/desorption cycles. With optimization and scaling, this approach holds strong potential for treating large bodies of metal-contaminated water and expanding access to safe drinking water worldwide.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
233	PS	6085

Title: Functionalizing DNA Nanotechnology: Optimizing the Impact of Buffer Conditions on Chemical Ligation

Student Name(s): C. Chan

Abstract:

The field of DNA nanotechnology removes DNA out of its biological context and instead utilizes DNA as a building block to form 2D and 3D structures with a wide variety of applications, ranging from nanoelectronics to medicine. Ligation of DNA plays a crucial role in assembling DNA crystals, providing stability to the construction of otherwise fragile structures that are sensitive to changes in pH and temperature. 1-ethyl-3-(3-dimethylamino (propyl)) carbodiimide (EDC) shows promise as an alternative to DNA ligation in nanoscale environments where alternatives, such sticky end cohesion and enzymatic ligation, remain impractical. Previous studies have shown success of EDC ligation between DNA-protein cocrystals, however, EDC ligation for double-stranded DNA strands (dsDNA) remains unpredictable, with as low as 30% efficacy. ImageJ was used for the densitometry analysis of ethidium bromide-stained polyacrylamide gels to investigate EDC ligation efficacy of different dsDNA reaction conditions, including pH, buffer concentration, temperature, and additional EDC buffer additions. It was found that EDC can ligate dsDNA, demonstrating novel potential for building robust DNA nanostructures. The reaction was found to occur most optimally at higher temperatures and a lower pH and buffer concentration, with its efficacy optimized to nearly 100%. The results of this proof-of-concept study provides insight into EDC's efficacy for the ligation of dsDNA and the optimization for the reaction for potentially assembling more diverse 2D and 3D DNA nanotechnologies.

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

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
251	PS	6086

Title: The "Why" Behind the Move

Student Name(s): A. Low

Abstract:

The purpose of this project was to create my own Sudoku-solving algorithm and compare its speed and accuracy to a basic backtracking method and Peter Norvig's Sudoku solver, which uses constraint propagation combined with search. I also created a full Sudoku game with a graphical user interface, using the solvers to sort puzzles by difficulty so players could access a myriad of boards. To investigate performance on puzzles of different difficulties, I tested each solver on 200 Sudoku puzzles collected from books, websites, and puzzles to verify correctness and establish baseline performance. After confirming the code functioned properly, I tested the solvers on a dataset of one million Sudoku puzzles and solutions. I also ran additional benchmarks on a smaller controlled set to measure detailed performance. Difficulty was estimated by the number of empty cells, since puzzles with fewer starting clues are generally harder. For each puzzle, I recorded whether the solver found the correct solution and how long it took to solve. My results showed that Norvig's solver was the fastest and most reliable on puzzles with many empty cells, while my algorithm performed best on easier puzzles with fewer empty cells because it relied mainly on logical deductions and needed less guessing. The basic backtracking method was usually slower than Norvig's, especially on harder puzzles where constraint propagation reduced the search space. Overall, different algorithms perform better depending on puzzle difficulty. Simpler logical strategies were effective for easier boards, while more advanced techniques were needed for harder ones.

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

2026

Word Count	Fair Category	Project Number
258	PS	6087

Title: A Robust Computational Framework for Solar Particle Event Detection: Integrating Convolutional Neural Networks with Multivariate Physical Proxies

Student Name(s): I. Jaiswal

Abstract:

The objective of this investigation was to develop a high-precision predictive system for Solar Particle Events (SEPs), which pose a threat to global technological infrastructure. SEPs consist of high-energy protons accelerated to relativistic speeds. Upon impact, these particles can induce single-event upsets in satellite electronics, permanently disabling critical orbital technology, and deliver harmful radiation doses to astronauts. Current warning models are frequently compromised by satellite telemetry instability, where sensor dropouts and signal noise during peak solar activity lead to critical detection failures. This research addresses the need for a resilient forecasting framework capable of maintaining reliability during hardware compromise. I tested if a hybrid model, synthesizing convolutional neural network (CNN) analysis with custom physics-derived features, could isolate SEP signatures from background solar wind noise. The procedure was done in Google Colab and processed time-series datasets from NASA's OMNIweb service, specifically analyzing Solar Cycles 22-24. A CNN was trained on this multivariate data, followed by a validation phase using 47 high-impact event samples. Feature transformations included logarithmic scaling of proton flux and Delta-Velocity calculations to detect shock-front arrivals. A composite kinetic proxy was engineered to characterize the interaction between particle density and velocity, which served as a second validation layer. Results demonstrated a validation accuracy of 85.1% and a storm-event precision of 0.89, outperforming standard threshold models. This project offers a viable early-warning framework that can allow us to preemptively protect satellite technology, minimize data corruption in global communication, and provide warnings to stabilize power grids against induced surges.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
260	PS	6088

Title: Real-Time Instance Segmentation for Curb and Path Detection in Assistive Wearables for Blind and Low-Vision Assistance

Student Name(s): O. Ajayi

Abstract:

Safe navigation remains a major challenge for individuals with blindness or low vision, as traditional mobility tools such as the white cane provide limited advance information about ground-level hazards like curbs and uneven walking surfaces, with 46.7% of severely visually impaired seniors reporting an injury-inducing fall per year. While electronic travel aids improve environmental awareness, many struggle to simultaneously provide effective navigation and reliably detect critical pathway features—curbs, sidewalks, and roads—in real-world conditions. This research investigates whether real-time instance segmentation using the YOLOv11 deep learning framework can perform both tasks within wearable assistive navigation technologies and outperform traditional mobility tools. We hypothesize that a YOLO-based segmentation model can achieve detection accuracy sufficient to comprehensively support safe travel. A custom dataset was collected using a wearable RGB imaging device and annotated with segmentation masks representing pathway features. The YOLOv11 model was trained using supervised learning and evaluated using precision, recall, confusion matrix analysis, and mean average precision across multiple intersection-over-union thresholds. The trained model achieved precision and recall values above 0.75, with an mAP50 of 0.86 and an mAP50-95 of 0.72, exceeding performance reported for state-of-the-art vision-based ETA systems at averages of 50–80% for mAP50 and <70% for mAP50-95. Errors occurred primarily between visually similar classes, while validation results demonstrated strong generalization across varied environments. These results indicate that deep learning-based segmentation can provide accurate hazard detection and situational awareness in assistive wearables, creating a foundation for real-world integration and user testing within ETA systems.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
256	PS	6090

Title: Evaluating Post-Pandemic Recoveries in Standardized Test Scores across Connecticut School Districts and their Explanatory Factors

Student Name(s): A. Ganisshan

Abstract:

The quality of a child's education in Connecticut is decided by their place of residence, and this problem may worsen if Education Cost Sharing (ECS) funding remains constant this year. These inequities are most apparent in school districts with the highest concentrations of low income families, as highlighted through the analysis of DRGs. The District Reference Group (DRG) is a ranking of school districts across the state based on socioeconomic status and resource availability, lettered from A to I (A highest; I lowest). The goal of this research project was to apply the DRG of Connecticut school districts as an explanatory variable to see whether they relate to the rate of post-pandemic rebounds in schools. This was measured using standardized testing data. The 2018-2019 (pre-pandemic) SBAC scores for 7th graders and 2022-2023 (post-pandemic) SAT scores for 11th graders were the primary focus of analysis. School districts in CT were organized according to their DRG, and Z-scores for each district were calculated for both the SBAC and SAT. The Z-scores were utilized to create a scatterplot, and rebound scores were used to conduct a T-Test in order to compare the average rebound scores of higher and lower ranked DRGs. The T-Test resulted in a P-value of 0.006, with a significance level of 0.05. Furthermore, the scatterplot clearly indicated lower rebounds among lower ranked DRGs, while more prevalent rates for higher DRGs. The results revealed that DRG ranking did impact the strength of rebounds in lower and higher ranked DRGs.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
182	PS	6091

Title: Post-Robbing Behavioral Shifts in Native and Invasive Bees

Student Name(s): S. Nehro

Abstract:

The western honey bee, Apis mellifera, though a widely valued crop pollinator, has become an invasive species that competes with native species (Bombus impatiens) for resources, primarily nectar. One mechanism by which A. mellifera gains access to nectar is primary robbing, in which bees bite holes in the base of flowers, and is subsequently exploited by other pollinators through secondary robbing. This study aims to understand how the presence of robbing holes affects the abundance, composition, and foraging behavior of both native and invasive pollinators after nectar robbing has occurred on a flower native to Connecticut, Monarda fistulosa. Specifically, average pollination time, visit location, and pollination frequency. It is hypothesized that the introduction of nectar robbing will decrease pollination frequency and pollination time of native species, and will increase visitation rates of invasive species. Examining how visitation location differs will help explain why some plants experience reduced pollination when invasive bees dominate, even if total visitation rates appear high. Understanding the interactions between invasive and native bees will help inform decisions on how best to protect biodiversity and maintain a healthy ecosystem.

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

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

2026

Word Count	Fair Category	Project Number
253	PS	6092

Title: Modular Development of a Pneumatic Lumbar Exoskeleton for Assisting Stoop Lifting

Student Name(s): Y. Shan

Abstract:

Lower back pain (LBP) is the leading global cause of disability, affecting over 619 million people, particularly industrial handlers and sedentary office workers, and resulting in decreased work productivity and increased socioeconomic burdens. This research project focuses on developing a hybrid lightweight pneumatic lumbar exoskeleton that combines the advantages of both active and passive designs to provide effective lifting assistance and alleviate lumbar muscle strain.The exoskeleton is worn on the back and connected to the user's thighs, with pneumatic airbags positioned at the lumbar region. The device includes two detachable airbag layers for user customization, each consisting of two columns of three internally connected airbags. Gyroscopes and pressure sensors are integrated to automatically detect user motion and adjust internal airflow based on real-time tilt angle and air pressure data. Multi-variable experiments investigating air pressure, airbag layers, and load showed the device achieved up to 20 cm retraction and 3.5 kg assistive pulling force. The dual-layer structure provided significantly stronger support than a single layer, with a maximum retraction improvement of approximately 79%. However, gyroscope measurements were affected by user attire and long-term drift. To improve measurement accuracy and reliability, an external camera-based AI pose-estimation system was integrated, which acts as a stable, non-contact reference for body angle detection.The exoskeleton is suitable for industrial handling, healthcare, housework, and other scenarios requiring lumbar support during lifting or prolonged sitting. Future work will optimize material connections, motion recognition accuracy, and heavy-load performance to enhance wearing comfort and usability.

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

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

2026

Word Count	Fair Category	Project Number
248	PS	6093

Title: Optimizing the Efficiency of Solar Panels using Enhanced Cooling Techniques

Student Name(s): P. Manikandan

Abstract:

Solar panels are the fastest growing source of renewable energy yet these systems only convert about 15-22% of incoming solar energy into usable electricity, which is further reduced at high temperatures due to elevated operating conditions. Conventional photovoltaic systems lack integrated thermal regulation strategies to stabilize electrical output under sustained heat exposure. This research presents a thermally optimized hybrid cooling configuration; integrating passive and active regulation to enhance photovoltaic voltage stability under heat stress.

It was hypothesized that increasing the surface temperature of the panel would decrease voltage output, whereas implementing cooling methods would increase voltage. To test this, the investigation examined how thermal variation affects electrical performance. Four different conditions were tested: a control without cooling, a passive heat sink, an active thermoelectric cooler, and a combined heat sink and thermoelectric configuration. Temperature controlled units were utilized to simulate conditions ranging from 15°C to 40°C. Voltage and temperature were monitored over ten minute intervals.

Results showed that as panel temperature increased the control condition exhibited a voltage decrease of approximately 3-30%. In contrast the passive heat sink increased voltage by about 7%, the thermoelectric cooler by roughly 9% and the combined configuration by up to 16% under heat stress.

Future advancements will incorporate copper heat sink modifications to enhance the novel thermoelectric cooler and heat sink configurations. This research sets a new convention in modern renewable energy systems by improving the efficiency, cost effectiveness, and the weather dependency, paving the way for real world applications.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
158	PS	6094

Title: Designing Metalloid Bags to Reduce Static Build Up in Powders

Student Name(s): A. Gamble

Abstract:

Electrostatic charge buildup in powdered materials can cause clumping, material loss, and safety concerns during storage and handling. This experiment investigated the effectiveness of metalloid-lined bags in reducing static electricity in powders compared to conventional plastic bags, and evaluated whether electrical grounding enhanced this effect. Equal masses of powder were placed in three bag types: plastic (control), metalloid-lined ungrounded, and metalloid-lined grounded. Static charge was generated through triboelectric charging using friction from a PVC pipe and mechanical agitation. A homemade electroscope was used to quantify electrostatic charge by measuring leaf deflection angles before and after bag treatment. Percent reduction in static charge was calculated for each condition. Results demonstrated that metalloid-lined bags significantly reduced electrostatic buildup, with grounded metalloid bags producing the greatest reduction, supporting the role of conductive materials and grounding in electrostatic dissipation. And this was made to ensure that many big companies can get the most powder out of the bags.

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

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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

2026

Word Count	Fair Category	Project Number
167	PS	6095

Title: Innovated Vital Sign Detector

Student Name(s): R. Hu

Abstract:

Falls and sudden health emergencies pose serious risks for elderly individuals and people with medical conditions, especially when immediate assistance is unavailable. The purpose of this project was to design and evaluate a wearable Vital Sign Detector that continuously monitors vital signs and displays the user's condition through a shareable web-based platform. The wearable device is equipped with a heart-rate sensor and an inertial measurement unit (IMU) to measure heart rate and body movement in real time. Sensor data are transmitted to an online server and displayed on a dedicated website that can be accessed through a shared link, providing both a visual status indicator and quantitative data, including a numerical heart-rate value. The system was tested during simulated daily activities and controlled fall scenarios to evaluate detection accuracy and responsiveness. Results showed that the device reliably detected fall-like motion and abnormal vital-sign changes, and that both the color status and heart-rate values updated correctly on the website in real time.

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

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

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
249	PS	6096

Title: Optimizing Bus Fleet Allocation in Mid□Sized Cities Using Mixed□Integer Nonlinear Programming: A Case Study in Stamford, CT

Student Name(s): V. Makarov

Abstract:

Public bus systems in mid-sized cities often struggle to balance constrained operational resources with serving time-varying passenger demand and multi-modal travel patterns. In Stamford, Connecticut, a fleet of 40 buses must be allocated across 20 routes with rapidly shifting levels of passenger demand throughout the day while aligning with train arrivals at the Stamford Transportation Center (STC). The city's strategic development plan "STAMFORD 2035" prioritizes reducing bus headways and improving multi-modal connectivity; however, traditional scheduling tools – largely based on linear formulations developed in the 1990s – struggle to capture the time-dependent, nonlinear interactions inherent to real transit operations. This study introduces a Mixed-Integer Nonlinear Programming (MINLP) framework for optimizing bus allocation across routes and time blocks, which to reflect Stamford's operational day was applied as nine consecutive two-hour time blocks from 5:00AM to 11:00PM. When tested on four weeks of ridership data, the optimized schedules significantly outperformed those currently used by CTtransit Stamford: bus headways decreased by over 35%, alignment with train arrival windows at the STC increased by over 90%, and the number of buses activated only went up by 6%. Sensitivity analysis also showed there's a smooth trade-off between cost efficiency and service quality when adjusting the model's weights to reflect different policy priorities. Overall, this MINLP approach provides a computationally traceable and scalable tool for data-driven scheduling in resource-constrained transit systems, providing a foundation for future extensions to incorporate additional operational constraints and real-time parameter adjustment

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
248	PS	6097

Title: Process Optimization of Green Chemistry Pathway for Fabric-to-Fabric Recycling of Cotton

Student Name(s): M. Wies

Abstract:

An estimated 92 million tons of textiles are discarded annually, yet fabric-to-fabric recycling accounts for less than 1% of production due to reduced quality and financial barriers. This research develops a green chemistry pathway for closed-loop recycling of cotton, strategically targeting cutting room waste streams where 16-21% of fabric is discarded. Utilizing aqueous sodium hydroxide, the process deweaves cotton fabric and despins yarns into spinnable staple fibers. Systematic optimization of process variables identified two optimal protocols: treatment in 4M NaOH at 50°C for 30 minutes achieved 71.63 ± 4.29% fiber recovery (n=4), while room temperature processing for 120 minutes yielded 70.13 ± 3.04% recovery with lower energy expenditure at laboratory scale. Both protocols utilized presoaking and mechanical stirring at 300 rpm. Preliminary solvent reuse studies indicate potential for industrial waste reduction, as fabric deweaving was sustained across four consecutive cycles without solvent replenishment. Although recovered fiber staple length (2.17 ± 0.08 cm) was shorter than virgin cotton (3.2–3.8 cm), fibers were successfully incorporated into yarns at 20% recycled content – approximately double commercial recycled cotton standards. FTIR spectroscopy confirmed retention of cellulose I structure with partial cellulose II characteristics. The re-spun yarns were woven into new fabric, completing the closed-loop cycle. This work aligns with Green Chemistry Principles of waste prevention, safer solvents, and energy efficiency. The approach establishes a fabric-to-fabric recycling pathway that offers an alternative to landfilling or downcycling, preserving material value while reducing dependence on environmentally intensive cotton agriculture.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
147	PS	6098

Title: Assessment of walking ability in Parkinson's patients using three-dimensional plantar pressure sensors

Student Name(s): T. Zhang

Abstract:

As the world population enters an aging era, the situation of Parkinson's disease is becoming increasingly severe. The clinical manifestations of Parkinson's patients mainly include tremors, walking disorders, muscle rigidity, and bradykinesia, among which walking disorders and bradykinesia are the more obvious features of Parkinson's patients. The existing gait analysis methods mainly include image analysis, wearable sensor analysis, and plantar pressure testing platform analysis. Among them, wearable sensor analysis is expected to solve the long-term and low-cost gait detection needs. However, currently wearable sensors cannot measure the tangential force on the sole of the foot, resulting in the inability to obtain complete plantar force information of patients, which poses difficulties for more accurate gait analysis. This project designs a three-dimensional force sensor and measurement method for the sole of the foot, and uses machine learning algorithms to evaluate the walking ability of Parkinson's patients.

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

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☒ Yes ☐ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
256	PS	6099

Title: Hybrid Neural Heuristics for Faster Real-Time Path Planning

Student Name(s): A. Tsang

Abstract:

Path planning is important in robotics, autonomous navigation, and game AI, but classical search algorithms such as A* and Dijkstra can become computationally expensive in cluttered environments because they must expand many nodes before reaching a goal. This project investigated whether learned spatial guidance could reduce search effort while preserving path quality. I hypothesized that combining a learned corridor predictor with a learned heuristic would allow a search algorithm to find paths more efficiently than standard A*.

To test this, I generated datasets of two-dimensional obstacle maps and computed optimal shortest-path costmaps using Dijkstra's algorithm. I then trained two U-Net models: one to predict a normalized costmap from a grid and goal, and a second to predict a "pathmask" representing a corridor containing the optimal path. These learned outputs were integrated into a hybrid planning system in which the pathmask restricted the search region and the costmap provided a neural-clamped heuristic for A*.

On a validation dataset of 400 maps, the hybrid planner reduced median planning time to 68.7% of standard A* and reduced median node expansions to 58.4% of standard A*, while preserving optimal cost in the median case. On maze-like maps, the hybrid planner reduced median planning time to 64.5% of A* and median node expansions to 54.3% of A*, outperforming neural-only A* and Weighted A* on those maps. These results indicate that combining learned corridor prediction with learned heuristic guidance can accelerate graph search in structured environments and may improve real-time path planning in autonomous systems.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
253	PS	6102

Title: Evaluation of Environmental Parameters and Design Optimization for Kirigami-Inspired Parachutes

Student Name(s): A. Ukidwe

Abstract:

Drone delivery is an emerging technology that is gaining traction with large businesses including Amazon Prime Air, Walmart and others. It is also being increasingly utilized to deliver humanitarian aid in hard-to-reach areas such as those affected by natural disasters or conflicts. Accurate and reliable delivery of packages is of paramount importance especially when they are dropped from a height. Parachutes are often employed to ensure a smooth and gradual descent to protect the payload. Traditional parachutes require a gliding angle for stability and show poor terminal accuracy especially in adverse weather conditions such as wind or rain.The project strives to investigate how different patterns inspired by the Japanese art of Kirigami and materials of construction affect the time of descent and the accuracy of delivery. This was done by cutting various slit patterns in paper or plastic disks, attaching home-made payloads, and dropping the parachutes from a set height. Experiments were repeated to capture inherent uncertainty in measurements. The results were not always intuitive and showed that larger disks offered slower descents, concentric slits in a staggered pattern offered better unfurling, polyethylene parachutes exhibited superior performance to those made from paper, and time of descent went through an optimum as concentric slits extended from the center to the outside diameter of the disk. These conclusions have direct implications to designing cost-effective drone deliveries. Further extensions of the research idea are possible and would include refinement of design through wind tunnel testing or fluid dynamic simulations for targeted delivery.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
231	PS	6105

Title: Energy-Optimal Control of Robotic Motion Under Discontinuous Friction

Student Name(s): V. Chaturvedi

Abstract:

Robotic systems operating in real-world environments frequently encounter abrupt changes in surface friction, such as transitions between smooth flooring, carpet, gravel, or loose debris. Most conventional motion-control algorithms assume friction is constant or smoothly varying, an assumption that breaks down under sudden frictional changes and can lead to excessive energy consumption, degraded performance, or instability.

This paper develops and simulates a mathematically rigorous control framework for robotic motion under variable and discontinuous friction. Frictional uncertainty is modeled explicitly as a stochastic jump process, allowing sudden losses of traction and regime-dependent dynamics to be represented within the system model. An energy-based objective is formulated, and an optimal feedback control law is derived using dynamic programming and the Hamilton--Jacobi--Bellman (HJB) equation in the viscosity-solution sense, ensuring global optimality without requiring smooth system dynamics.

A numerical implementation based on a jump-consistent Euler--Maruyama simulation scheme and a compound-Poisson-consistent HJB backup operator is constructed to evaluate the proposed controller against standard baselines, including a smooth-model HJB controller that ignores jumps, nominal LQR, and adaptive friction compensation. Performance is compared using total cost, energy usage, stability, and terminal error across paired randomized trials.

The methodology establishes a principled and reproducible pathway for quantifying when explicit discontinuous-friction modeling provides measurable benefits in energy efficiency and robustness, especially under frequent traction transitions and severe slip events.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
259	PS	6109

Title: Open Alert: a Novel and Affordable Device for School Safety

Student Name(s): B. Kiev

Abstract:

There has been a rise in violent incidents in schools. Also, phones are being taken away from students while in school, so parents are demanding an alternative way for students and staff to call for help in case of an emergency. The proposed device must be inexpensive to eliminate cost barriers for schools, and follow the statutes put forth by Alyssa's law that requires silent alarms be available in public schools. Open Alert is the solution to all such issues. Both parts of this system were constructed and powered by C++ in this investigation. The in-classroom devices have two buttons attached to an ESP-32-CAM with a UPS. All the in-classroom devices across a campus, ideally one per room, would communicate to each other through a mesh network without requiring an existing network to function. The substation will reside in the security office. It contains a UPS, buzzer, and LCD; all controlled by an ESP-32-DEV board. The device connects to the mesh network set up by the in-classroom devices to receive any distress messages asking for help. After a call for help is received, the substation decodes the message, displays the room number where the call initiated, and starts a buzzer to alert people in the office of an emergency. The current system built serves as a working proof-of-concept, warranting further development. The system satisfies the originally put forth goals of being an inexpensive silent alarm, accessible by students and staff alike. Future prototypes will include a camera for more information.

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

2026

Word Count	Fair Category	Project Number
102	PS	6110

Title: Development of Versatile Casting Molds for Epoxy and Other Materials Using Compliant Mechanisms

Student Name(s): T. Gerlach

Abstract:

Molds for various materials (metals, thermoset plastics, thermoplastics concrete, plaster, ceramics, etc.) take effort, time, and resources to make for each new design. This project uses compliant mechanisms to develop one single flexible mold that can create differently shaped objects. I created a first prototype that had one soft robotic actuator and the mold could create two different designs out of epoxy. I created a second prototype that had four soft robotic actuators and could create 24 different designs of epoxy. Such a versatile mold is a new rapid prototyping technique which will save time and money and allow for design flexibility.

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

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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

2026

Word Count	Fair Category	Project Number
246	PS	6111

Title: NeuroMirror: A Hebbian-Theory-Based EEG-Driven Mirror Therapy System for Post-Stroke Upper-Limb Rehabilitation

Student Name(s): S. Liu

Abstract:

Stroke is a leading cause of long-term upper-limb motor impairment because it disrupts sensorimotor neural pathways, limiting patients' ability to regain voluntary function through conventional rehabilitation. This project addresses the need for therapies that both engage and measure underlying neural activity during training. NeuroMirror is a closed-loop "neuromirror" rehabilitation system that combines mirror therapy with real-time EEG monitoring to enhance Hebbian neuroplasticity. The central aim is to synchronize motor intention, sensory feedback, and visual input to strengthen residual sensorimotor connections. NeuroMirror comprises three integrated components. First, a 16-channel EEG system is engineered with high input impedance, low-noise amplification, and isolated digital–analog power to reliably capture sensorimotor rhythms. Second, a visual tracking module estimates the movement of the healthy hand and drives an intelligent rehabilitation glove to actively assist the impaired hand, transforming traditional passive mirror therapy into intention-driven bilateral training. Third, the system quantifies motor engagement by tracking event-related desynchronization (ERD) in the μ (8–12 Hz) and β (13–30 Hz) bands as neural markers of sensorimotor activation. In experiments, mirror vision with passive movement reduced μ- and β-band power by 67.7% and 74.5% relative to baseline, while adding explicit motor intention further increased μ-band ERD to 93.5%. These results indicate that combining visual input, proprioceptive feedback, and motor intention produces strong Hebbian effects and demonstrate that NeuroMirror can transform mirror therapy into an adaptive rehabilitation platform that reinforces neural activation during stroke recovery.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
251	PS	6114

Title: Analyzing PKB activity and ROS within Dictyostelium discoideum cells via capillary electrophoresis

Student Name(s): N. Newhouse

Abstract:

Protein kinase B (PKB) is an enzyme that is important to cellular regulation and cell survival. Dictyostelium discoideum cells are a unique model organism for studies of cellular heterogeneity in stress response. In D. discoideum, PKB activity is regulated by reactive oxygen species (ROS), including nitric oxide and superoxide. To better understand the signaling connections between PKB and ROS, we developed a capillary electrophoresis (CE) method to analyze signaling through protein phosphorylation and small molecule ROS. To analyze cellular enzyme activity, a fluorescent peptide substrate reporter is loaded into these cells, where it is modified. We are interested in assaying PKB activity in individual intact cells; however, most peptides are not membrane permeable. A caged peptide substrate reporter is absorbed by the cells, but the peptide only reacts when uncaged. After the caged peptide passes through the membrane, the peptide is then uncaged through ultra-violet (UV) light exposure. Uncaging trials were completed to determine the uncaging rate of the caged peptide under various conditions. Additionally, we conducted experiments with different ROS indicators that are used to measure other D. discoideum cellular activities. These experiments allow us to adjust the parameters of our peptide experiments to fully see phosphorylation in CE electropherograms without interference from ROS indicators. Moving forward, we will work on identifying sources of peptide degradation as it affects peptide reporter efficiency. We ascertain the best conditions to ensure cell survival under the UV and develop a procedure that can be used to analyze phosphorylation and ROS levels simultaneously.

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

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- ☐ vertebrate animals
- ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No
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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
101	PS	6115

Title: AI-based adaptive street safety assistant for the visually impaired

Student Name(s): K. Nascimento

Abstract:

The purpose of this project was to develop a methodology to detect crosswalk obstacles for blind people. Iterative cycles of code were generated by AI in Python to complete the task. The AI was trained using a set of images that were uploaded and key features were identified. The detection software successfully detects different types of vehicles. If the right angle is visible, curbs are successfully identified as well. Stop lights and crosswalk lights are intermittently successful and still undergoing iterative design. The software will eventually be integrated into a Raspberry Pi with detectors in the second phase of the project.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
249	PS	6118

Title: Health-Track AI

Student Name(s): A. Sadhvani

Abstract:

Many humans suffer from illnesses that could have been treated with early detection and consistent care. Using a mobile application with an integrated AI model to diagnose illnesses is a viable method to provide an accessible, affordable, and accurate way of detecting medical conditions. Employing an autonomous robotic care system consisting of an autonomous robotic arm and vision system is a practical choice for a continuous care system, because it provides necessary assistance, without human involvement. The goal for the Robotic Care System (HT-RCS) was to be capable of object manipulation, assisting patients with difficult tasks.

The performance of many AI architectures used for early detection, including a Tabular Transformer, Linear, and LSTM Neural Networks, developed using PyTorch, were evaluated using percent accuracy, total correct diagnoses divided by total diagnoses. The performance of HT-RCS, made up of a tri-joint arm, and a vision system that utilizes stereoscopic vision, and YOLO object detection was investigated in real-world scenarios through evaluation of the arm's motion, detection of items, and stereoscopic calibration tests.

Results indicate that the LSTM Model performed best, with an accuracy of 90 percent, outperforming the physician control of 85.6 percent. It was found that HT-RCS met its criteria because it was capable of detecting common objects, passing stereoscopic calibration tests, generating depth maps, and the arm was capable of XYZ motion. These results show that the LSTM Model developed can detect illnesses early, and that HT-RCS is capable of providing continuous care.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
232	PS	6119

Title: Medication Management

Student Name(s): A. LaMonico

Abstract:

Managing medications and precise pill-taking is a crucial component of patient safety, especially for individuals with complicated pill regimes or memory challenges. Automatic timer pillboxes are designed to improve medication adherence by providing reminders and delivering pills at preset times. This helps reduce the risk of missed or double doses. This project tests the versatility of an automatic timer pillbox by comparing the pill delivery performance across different pill sizes and weights. The pillbox was constructed using household materials such as cardboard and popsicle sticks, then was coded and programmed using an Arduino kit and a servo motor to dispense the pills when an alarm sounded and a button was pressed. Three different medication types were used to represent large/heavy pills, capsule pills, and small/light pills, with each type undergoing three trials. The amount of time that was taken for the pillbox to deliver the pills was measured. The smaller, lighter pills were delivered more quickly than the larger, heavier pills, refuting the original hypothesis that states how increased pill sizes would decrease the delivery time due to gravitational forces. Despite variations in delivery times, all pills were dispensed consistently, demonstrating the pillbox's versatility across different pill types. These findings suggest that while pill size and weight influence delivery speed, the automatic pillbox remains reliable and adaptable, demonstrating the device's potential to improve real-world medication adherence and safety.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
194	PS	6122

Title: LISTEN – A Robotic Leak Identification System using TDNN and ENhanced Acoustic Features for Pipeline Detection

Student Name(s): J. Li

Abstract:

Gas pipeline leakage leads to serious environmental, economic and mortal risks, yet current detection methods often rely on manual inspection, stationary sensors, or drones with methane sensors, which suffer from low efficiency, limited coverage, and inconsistent accuracy under varying conditions. Aiming to solve the problem, the project proposes “LISTEN,” a robotic Leak Identification System using TDNN and ENhanced acoustic features for pipeline detection. The robot's structural components are totally 3D printed and then assembled with electrical components such as the microphone or the Raspberry Pi where a novel AI algorithm, ECAPA-TDNN, is deployed. The experimental setup was implemented in the school laboratory, where different pipeline leakage conditions were systematically simulated. Audio samples were collected under varying pressure conditions (0.2 bar and 0.5 bar) and different leakage configurations (1.5 mm hole, 5 mm hole, and 35 mm × 2 mm gap). Our algorithm can reach 95% accuracy in the test dataset even with background noises and our robot “LISTEN” can achieve continuous and accurate gas leakage detection during pipeline patrol operations. Our system “LISTEN" offers a promising acoustic-based robot for real-time, high-accuracy gas pipeline leakage detection in the industrial and municipal fields.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
248	PS	6124

Title: Quasi-Direct Drive Hip Exoskeleton for Gait Assistance and Metabolic Cost Reduction

Student Name(s): J. Zhao

Abstract:

With the increasing demand for wearable robotic devices in medical rehabilitation and industrial motion assistance, the limitations of single-function lower limb exoskeletons have become prominent, such as poor adaptability to complex motion scenarios and slow response of traditional control systems. This research focuses on the design and development of a multifunctional hip joint exoskeleton based on Quasi-Direct Drive (QDD) technology, aiming to solve the problems of low motion adaptability and inaccurate joint motion detection of existing exoskeletons. The research completed the overall design of the exoskeleton including mechanical structure, electronic hardware and software control system, adopted JY61P inertial measurement unit (IMU) for real-time joint angle detection, and designed a M8010 motor drive control system with RS485 communication and Bluetooth wireless control. A series of performance tests were carried out on the prototype, including joint angle detection accuracy test, motor response performance test and multi-gait mode adaptability test. The experimental results show that the exoskeleton can accurately capture the kinematic characteristics of human lower limb movement with the angle detection error within an acceptable range, and the motor drive system can realize stable and fast response of multiple gait modes such as level walking, stair ascent and downhill walking. The designed hip joint exoskeleton has the advantages of high control precision, strong motion adaptability and good human-computer interaction, which can provide effective mechanical assistance for lower limb rehabilitation training and high-load motion tasks, and has broad application prospects in medical and industrial fields

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
241	PST	6502

Title: Comparing the Emission of Known Irritants from Local Wood's Smoke Using Gas Chromatography-Mass Spectrometry (GC-MS)

Student Name(s): P. Delaney, C. Coughlin

Abstract:

Due to combustion byproducts, the inhalation of wood smoke containing alpha-pinene often causes respiratory issues (National Toxicology Program). The purpose of this project is to find the concentration of alpha-pinene emitted by cedar, pine, and aspen wood smoke, determining which wood has the highest possible chance of irritation and which one has the lowest. This information can help people understand the harms of smoke being released from burning wood. Pine was hypothesized to have the highest concentration of alpha-pinene in its smoke due to studies that show pine trees naturally produce alpha-pinene as a defense against insects and pathogens (Xu et al.). In the experiment, 3 samples of smoke from each wood type were collected and mixed with acetone. Three drops were taken from each sample, placed into separate GC-MS vials and diluted with acetone. The results collected were compared to pure alpha-pinene extract in order to determine concentration. Pine was the only wood with a detectable amount of alpha-pinene. However, aspen wood was identified to have a high concentration of dimethoxy compounds (phenols derived from lignin breakdown), which are known to cause irritation in the lungs (Singh et al.). Using alpha-pinene as a marker for irritation initially seemed logical but was not supported by results. From the results: cedar wood exhibits the lowest potential for irritation, pine wood exhibits moderate potential for irritation, and aspen wood exhibits the highest potential for irritation.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
86	PST	6504

Title: The Seizure Detecting Convolutional Neural Network

Student Name(s): J. Evans, C. McCreath

Abstract:

The objective of this project was to create a convolutional neural network (CNN) that detects seizures. By compiling a series of algorithms from OpenCV and training the neural network on a dataset consisting of seizure and non-seizure scenarios, the CNN was able to successfully identify 95.6% of seizures in the dataset it was trained on and 66.2% of new data it was given. Ultimately, this accuracy is insufficient compared to current seizure detection technology, and the CNN would not be reliable in real-world application.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
250	PST	6505

Title: Solutions for Broke Artists: A Low-Cost Activated Carbon Filtration System for Renewing Turpenoid

Student Name(s): S. Jiang, Y. Li-Zhou

Abstract:

Turpenoid is a petroleum-based oil paint thinner and brush cleaner that is typically disposed of after one use due to paint contaminating its opacity. The continuous disposing of Turpenoid can be financially and resourcefully wasteful, and can increase the chances of going into the environment. The consequences of this pollution can be extremely burdensome, as the material is combustible and extremely toxic to aquatic environments. Some artists wait for paint particles to separate from the solvent, but this method is time-consuming and not effective at producing a usable material. The goal of this project is to create a filtration system that can efficiently and effectively separate the Turpenoid from its contaminants so that it may be reused, reducing its financial and environmental burden. A tool made of activated carbon, mesh, and an empty plastic bottle was used to filter the material. The "sticky" nature of carbon when interacting with paint particles is optimal for the filtration. Using the filter results in a 99.29% increase in time efficiency and at least a 84.81% improvement in cost-effectiveness. Additionally, the absorbance of the solution after filtering decreased. With a 490 nm calibration, the spectrophotometer readings of the filtered solutions were 0.276, 0.328, 0.204, with 1, 2, and 3 layers of 200ct mesh respectively, compared to a higher absorbance of 0.347 with the unfiltered solution. These findings may not only aid future advancements in material-conserving projects, but also potentially slow the speed of environmental waste accumulation and lower artist expenditures.

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

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☐ Yes ☒ No

CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
248	PST	6506

Title: Real-Time Integration of a Compact Intracranial Pressure (ICP) Sensor to Benchmark NeuroProbe, a Multimodal Brain Monitoring Device

Student Name(s): A. Bulsara, J. Storeygard

Abstract:

Traumatic Brain Injury (TBI) is any alteration in brain function caused by an external force. Secondary Brain Injury (SBI) refers to the cascade of biochemical and physiological events hours to days post-TBI that aggravate the initial injury. Intracranial pressure (ICP) monitoring is important to limit SBIs, as an increase in ICP leads to damaged brain tissue. Multimodal neuromonitoring (MMM) is a technique that uses several simultaneous measurements to provide insight into the brain. MMM is becoming standard in the ICU, yet most monitoring practices rely on disconnected systems. NeuroProbe, in development at Yale, is a single-probe MMM device that measures EEG, ICP, brain tissue temperature, and oxygen levels in real-time. This project collected and analyzed data from a benchmark ICP sensor to determine Neuroprobe's readiness for predicate device clearance. A sealed water-filled chamber with a compact ICP sensor was connected to an infusion pump, and pressure was tested from 0 to 125 mmHg in two experimental phases. Phase 1 compared sensor output to computer-vision-derived pressure, and Phase 2 compared sensor output to theoretical pressure values based on the volume of water. Pressure values obtained through computer vision aligned with sensor measurements, with an R^2 of 0.9250. In Phase 2, the sensor demonstrated strong linear agreement with theoretical pressure values with an R^2 of 0.9956 and minimal drift. Overall, the sensor met the defined accuracy and stability constraints. This validation supports NeuroProbe development and suggests that improved multimodal monitoring can help to predict and treat SBIs more effectively.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
253	PST	6507

Title: Prometheus: Discovering Novel Quantum Critical Phenomena in Disordered Systems Using Unsupervised Deep Learning

Student Name(s): B. Yee, W. Collins, M. Rutkowski

Abstract:

Phase transitions govern phenomena from magnetism to superconductivity, yet characterizing them in complex quantum systems remains challenging because analytical solutions rarely exist and supervised methods require prior knowledge of phase structure. This project develops Prometheus, a variational autoencoder (VAE) framework for unsupervised discovery of phase transitions, critical properties, and order parameters across classical and quantum systems without labeled data.The framework was validated across four progressively complex systems. For the 3D Ising model (lattices up to 32^3 spins), a 3D convolutional VAE detected the critical temperature within 0.01% of Monte Carlo benchmarks and extracted critical exponents with 72% accuracy, identifying the 3D Ising universality class (chi-squared test, p = 0.72). For the transverse field Ising model, a quantum-aware VAE with fidelity-based loss detected the quantum critical point within 2% and discovered ground state magnetization as the order parameter (r = 0.97). For its disordered variant, the framework identified exotic infinite-randomness criticality, extracting tunneling exponent psi = 0.48 +/- 0.08 consistent with theory (psi = 0.5), the first unsupervised detection of activated dynamical scaling. For the frustrated J1-J2 Heisenberg model, a reduced density matrix VAE enabled scaling to 8x8 lattices, identifying the Neel-to-stripe crossover near J2/J1 approximately 0.55-0.6 (|r| > 0.96), contributing independent evidence to a three-decade debate in frustrated quantum magnetism with implications for high-temperature superconductivity and quantum material design.These results demonstrate that unsupervised learning can discover not only where transitions occur but what type of transition is present, establishing a general tool for exploring unknown quantum phase diagrams.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
186	PST	6508

Title: Green Light AI: Reducing Traffic-Related Emissions Using an Adaptive AI Sensor-Based Traffic System

Student Name(s): D. Bhatte, J. Pohl, S. Gaddam

Abstract:

The student-developed adaptive AI traffic system significantly outperformed traditional fixed-time signals by reducing vehicle stops by 77%. This engineering project developed an original adaptive traffic-control prototype to improve flow and reduce CO2 emissions. We independently built an interactive, multi-intersection traffic simulation using a coding interface in Visual Studio Code. A custom AI algorithm was authored to adjust signal timing based on real-time vehicle demand rather than a rigid schedule. Controlled trials compared this autonomous system against traditional timed signals. Simulation results demonstrated that the adaptive system reduced stops per vehicle from 12.6 to 2.9 and decreased average waiting time from 46.6 seconds to 22.3 seconds. Average vehicle speed increased from 38.9 mph to 44.4 mph, resulting in an estimated CO2 emission reduction of over 50%. To confirm practical feasibility, a physical two-way prototype was constructed using infrared break-beam sensors and a Raspberry Pi Pico W. Lightweight coding platforms, including Sublime Text and Replit, were utilized to maintain a low computational footprint during development. These results suggest that low-cost, student-developed adaptive systems provide a significant net environmental benefit.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
138	PST	6510

Title: How Effectively Can AI Classify Waste?

Student Name(s): A. Brewster, M. Larbi, B. Granados Pastora

Abstract:

As artificial intelligence becomes more prominent in society, we need to find ways to give back and combat environmental change. A significant portion of unsorted waste, particularly plastic ends up in landfills or oceans. Too much trash in landfills creates potent greenhouse gases that worsens climate change, and produces toxic liquid (leachate) that contaminates soil and groundwater overall destroying sacred habitats. To combat this, we developed a Computer vision model for a smart trash can, that improves waste sorting. We tested whether more or less images will improve accuracy to prove efficiency and credibility that our trash can will sort waste in their rightful compartments resulting in environmental benefits such as saving energy through the use of recycled material, decreasing landfill waste, cutting down air and water pollution for manufacturing new products, and overall protecting ecosystems and wildlife.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
254	PST	6513

Title: Evaluating the Efficiency of a Multifunctional Submersible for Microplastic Collection and Aquatic Environmental Analysis

Student Name(s): M. Zong, A. Ma

Abstract:

Microplastic pollution presents a persistent challenge in aquatic environments, particularly in subsurface regions where existing collection technologies are often prohibitively expensive and complex. This project aimed to design and evaluate an ultra–low-cost, highly maneuverable, multifunctional submersible capable of efficiently collecting suspended microplastic particles while monitoring water quality. It was hypothesized that a lightweight tri-propeller stabilization system combined with modular filtration units would maximize collection efficiency while maintaining affordability and precise navigation. A waterproof, remotely operated submersible was engineered at a total material cost of approximately $185—over 80% less than many commercial small-scale underwater collection systems. The platform incorporated three propellers for directional control, vertical stabilization, and tight-radius maneuvering. The collection system used interchangeable filtration cartridges for different plastic scenarios: a 500-micron mesh for macro-fragments, a 100-micron fine mesh for microplastics, and a density-optimized fiber filter targeting low-density polymers such as polyethylene and polypropylene. An adjustable-flow intake minimized turbulence and particle escape. Integrated sensors measured pH, turbidity, pressure, and depth in real time. Controlled tank trials showed peak collection efficiencies of 91% for larger fragments and 86% for fine microplastics under optimized flow, with consistent performance above 82% across repeated trials. The tri-propeller configuration improved maneuverability and precision. Continuous runtime reached 43 minutes per charge. Sensor data maintained ±0.1 pH accuracy and strong turbidity–particle concentration correlation.

These findings demonstrate that a low-cost, modular submersible platform can achieve high-efficiency microplastic removal while providing integrated environmental monitoring for scalable aquatic remediation.

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

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

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

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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

2026

Word Count	Fair Category	Project Number
154	PST	6514

Title: Enhancing Photostability of Aquazol® with the Addition of HALS

Student Name(s): H. Saunders, P. Saunders, . '

Abstract:

Aquazol®, a synthetic polymer, is used in art restoration and preservation as a consolidant, binder, or varnish; however, it is prone to photodegradation and discoloration when exposed to UV light. Some research suggests that photodegradation can be counteracted with the addition of Hindered Amine Light Stabilizers (HALS), compounds that scavenge free radicals. In this experiment, Tinvin 292 and Tinvin 770, two commercially available HALS, were combined with Aquazol to investigate the effects these stabilizers had on preventing the "yellowing" of Aquazol over time. Results indicate that when Tinuvin 770 was added to both Aquazol 50 and Aquazol 500, samples consistently exhibited less discoloration than the pure Aquazol control groups. Nearly all data were statistically significant, and the calculated R correlation coefficients were nearly linear. These findings have substantial applications in the field of art conservation, as the inclusion of HALS will help conservators restore and stabilize art with stable pigments less prone to yellowing.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
236	PST	6515

Title: Evaluating Biodegradable Polymer Materials as Sustainable Alternatives in Aerospace Engineering

Student Name(s): S. Nelakudity, S. Maddala

Abstract:

The aerospace industry relies heavily on petroleum-based polymers and composites because of their high strength-to-weight ratios and thermal stability. However, these materials contribute to long-term environmental impact. This project investigated whether a biodegradable polymer, polylactic acid (PLA), can be engineered to improve its mechanical and thermal performance while having environmental advantages over petroleum-based polymers and composites. PLA strips were printed at three infill densities (7.5%, 15%, and 30%) and tested for mechanical strength, thermal resistance, environmental durability, and biodegradation. Mechanical testing showed that increasing internal density significantly improved strength and stiffness, proving that design modifications to PLA can increase the load it can bear. Thermal testing showed that higher-density samples exhibited greater resistance to softening and deformation, suggesting that engineering adjustments can improve heat tolerance. Environmental durability testing revealed that PLA remains stable in neutral and basic water conditions, but degrades more in acidic environments. Biodegradation testing in soil showed that PLA undergoes measurable physical and structural breakdown over time, with lower-density samples breaking down more quickly. Overall, the results support the hypothesis that biodegradable polymers can be engineered to improve mechanical and thermal performance. Although PLA doesn't yet meet the extreme temperature requirements of aerospace applications, the experiment shows that use in low-heat, lightweight aerospace components can be successful. Additionally, it offers reduced environmental impact compared to conventional fossil fuel-based plastics that are currently in use.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
259	PST	6516

Title: Developing Eco-Friendly Sunscreen Formulations With Optimized Ingredient Concentrations to Reduce Zebrafish and Aquatic Ecosystem Toxicity

Student Name(s): A. Labhe, S. Nalamolu, C. Dixon Islur

Abstract:

Sunscreen pollution is an increasingly overlooked contributor to aquatic ecosystem damage through chemical runoff into waterways. Although some commercial UV-protectants are marketed as eco-conscious, many still contain chemicals such as nano-sized titanium dioxide, oxybenzone, and octocrylene, which can shorten zebrafish lifespan, disrupt reproduction, and stunt growth. Zebrafish are used widely in biomedical research as they share approximately 84% of disease-related genes with humans. This project aimed to develop and evaluate alternative sunscreen formulations designed to reduce potential environmental harm while maintaining effective UV protection. Experimental formulas were created using naturally derived ingredients including shea butter, coconut oil, beeswax, sea kelp powder, and non-nano zinc oxide. Formulations contained varying concentrations of non-nano zinc oxide and sea kelp powder. Their effectiveness was evaluated based on its ability to block UV radiation. A control group of nine uncoated UV-sensitive beads was exposed to a UV lamp in 10-second increments to establish baseline UV intensity. Each formula was evenly applied to UV beads and exposed to the same UV lamp for 90 seconds under controlled conditions. Constant variables included lamp type, bead type, exposure duration, and distance from the light source. Formula 3 produced minimal color change in the UV beads, indicating stronger UV protection than the other formulas. This effectiveness is likely due to its 10% non-nano zinc oxide and 20% sea kelp powder composition. Overall, this project strengthens the possibility of formulating a sunscreen that effectively blocks UV radiation while using ingredients that are considered less harmful to aquatic organisms, including zebrafish.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
196	PST	6518

Title: Water purification and energy generation using limestone roofing

Student Name(s): C. Andrews, R. Keyes, K. Miranda

Abstract:

Our experiment investigates if rainwater can become purified using building materials and if there is enough to create energy. We explore being able to clean rain water for drinking and create energy for the people of the world. In Bermuda it is believed that rainwater gets purified by the limestone stone roofing in UV light. Bermuda also has heavy periods of rainfall and we want to know if it would be enough to generate energy by running down the roof into the gutter system and spinning the turbine to generate the electricity. There is a control test with an asphalt roof and separate gutter system. We built the basic framework of a roof using a simple home made gutter system to catch the rainwater, attach the shingles and limestone to separate roofs, and make the circuit for the water wheels. The experiment shows that heavy rainfall will produce enough flow of water possible to generate electricity and the roof materials have an effect on the quality of the water. We are doing this project to help reduce the amount of fossil fuels used to produce energy, and to increase access to drinkable rainwater available to everyone.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
262	PST	6523

Title: A Nuclear Magnetic Resonance Spectroscopy Study of Five Di-imine Molecules

Student Name(s): E. Figlar, A. Abernethy

Abstract:

Nuclear Magnetic Resonance Spectroscopy (NMR) is a process used to determine the chemical environments of hydrogen and carbon atoms. The study, A Nuclear Magnetic Resonance Spectroscopy Study of Five Di-imine Molecules by Anahit Abernethy and Eva Figlar, done at Sarah Lawrence College under the guidance of Dr. Colin Abernethy, aims to test five different aniline compounds to determine if they can serve as sufficient models for procedures using benchtop NMR. The compounds analyzed in the NMR Spectroscopy machine were synthesized using acetic acid, the precipitate was separated from the solution using a vacuum filtration system, and the powder from the solution was diluted using the NMR solvent: chloroform. Specific molecules provided cleaner readings on the NMR machine than others. The accuracy of data was measured if it included the correct number of signals and the integration ratios for both carbon-13 and hydrogen atoms. 2,4,6-trimethyl-phenyl-diazabutadiene, 2,6-diethyl-phenyl-diazabutadiene, 2,6-diisopropyl-phenyl-diazabutadiene, and 2,6- dimethyl-phenyl-diazabutadiene all gave accurate data. 4-bromo-2,6-dimethyl-phenyl-diazabutadiene did not yield accurate information, even with additional measures taken, such as increasing the number of scans and the concentration of the substance. It was determined that more soluble molecules are easier for the NMR machine to scan, and therefore, more soluble molecules yield more accurate data and contribute to better models. NMR is one of the fastest growing fields in chemistry, so by determining an array of molecules suitable for NMR education, future generations will be able to utilize these molecules, which produce clear NMR proton and carbon spectra.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
59	PST	6524

Title: Robotic Arm

Student Name(s): D. Velasquez, J. Medina-Calderon

Abstract:

This project helps to build a robotic arm designed to lift a water bottle. It helps people complete tasks that require strength or extended reach. The arm uses a base, joints, and a gripper to move and securely hold objects. It performs well when holding light items but is limited by its cardboard construction and cannot lift heavy objects.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
242	PST	6526

Title: A Site-General Predictive Framework for Bioremediation: Integrating Meta-Analyses and In Silico Simulations to Optimize Brownfield Restoration

Student Name(s): G. Handa, N. Joseph

Abstract:

Anthropogenic contaminants, including hydrocarbons and heavy metals, jeopardize ecosystem health and public safety at over 450,000 EPA-designated brownfields across the United States. Bioremediation mitigates this risk by utilizing biological agents under controlled environmental parameters such as temperature and soil geochemistry. However, the lack of generalized semi-empirical formulas to predict bioremediator efficiency across diverse sites renders remediation efficacy highly site-specific. To bridge this gap, a meta-analysis was conducted to extract kinetic constants from literature, which were used to parameterize a novel in silico simulation. Species lacking sufficient experimental characterization were assigned conservative default kinetic parameters representing an average bioremediator, ensuring continuity while preventing overestimation of remediation efficiency. This deterministic model generated 5,000 simulated trials across 10 species, applying Michaelis-Menten kinetics and Gaussian penalty functions to quantify consumption across unique testing scenarios. The resulting dataset was used to construct species-specific multiplicative models. To simulate real-world variance, model performance was evaluated against a stochastic benchmark, yielding a log-log $R^2 = 0.611$ and a slope of 1.094. This indicates accurate predictive scaling across multiple orders of magnitude. Heavy metal remediation demonstrated the highest predictive stability (RMSE = 0.43 mg/kg/day), outperforming VOC (0.66) and hydrocarbon (0.71) models. SHapley Additive exPlanations (SHAP) identified pH and temperature as the primary drivers of variance, facilitating the development of a site-specific selection algorithm. These algorithms provide a scalable framework for accelerating ecosystem recovery, potentially reducing site assessment costs and accelerating brownfield redevelopment.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
256	PST	6527

Title: Evolution and Sustainability of U.S. Coinage

Student Name(s): G. Zhang, A. Zhu

Abstract:

This study investigates the variance in weight of the U.S. Lincoln pennies produced during different historical periods, with a focus on three hypotheses. The first hypothesis examines whether wartime production of 1943 Lincoln cents resulted in a higher variance in weight compared to peacetime 1954 cents due to manufacturing pressures from World War II. An F-test for equality of variances yielded a non-significant result ($p = .710$), indicating no statistically significant difference in weight variance between the two groups. However, a supplementary z-test revealed a significant difference in the pass rates（which means to fulfill the requirement of US minting law) of 1943-P (88%) versus 1954-P (95%), supporting the hypothesis that wartime production may have introduced variability due to external pressures. The second hypothesis tested whether the introduction of a zinc core in 1983 improved manufacturing precision, predicting a lower variance in 1983-P Lincoln cents compared to 1982-P. The F-test results ($p = .653$) showed no significant difference, suggesting that the compositional change did not affect variance significantly. Furthermore, an analysis of the weight reduction in 1982-P coins, due to rising copper prices, indicated a significant weight difference from the expected population mean.The third hypothesis explored whether manufacturing precision improved from 1954 to 1982, an F-test revealing a significant difference in variances ($F = 39.35$, $p = .0000073$), indicating improvements in minting technology. These findings indicate that Wartime manufacturing (external pressure including tariff)reduced minting precision.Modern minting technology maintains high quality during changing material. Economic pressure drives systematic weight reduction.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
248	PST	6528

Title: Proximity to Artificial Reef as a Predictor of Sediment Profile: Modeling Success of Living Shorelines Reefs

Student Name(s): C. Hutchins, M. Almachi

Abstract:

The use of living shorelines to reinforce and manage coastlines has recently grown, however, metrics of success need further assessment to gauge whether impacts are happening to local ecosystems. In estuaries, this relies on sediment profiles as a proxy to energy within the immediate coast. Clams, crabs and juvenile fish use this habitat for sensitive nursery habitat, and we need to properly assess whether needed ecosystem services are being provided. This study was designed to evaluate whether sediment profiles, and subsequently diversity of habitats are being altered by living shorelines initiatives in coastal New Haven Harbor. It was expected that not only would we see shoreline protection as has been previously documented in the literature, but sediment profiles will be larger inside of the reef versus outside. A random grid inside and outside of the reef were used to evaluate this, with research students collecting sediment samples at each. Upon sieving and processing each (n=11), significantly larger sizes were measured inside the reef (2.66 µm inside versus 2.16 µm outside, $p<0.05$). This, combined with the emerging pattern of peak grain size tending to happen progressively closer to shore led us to conclude sediment size and general energy levels in this ecosystem are indeed impacted by artificial reefs. This is significant as we continue to engineer our shorelines looking for ways to both preserve ecology and protect against natural disasters. A much needed follow-up lies in the potential impact this has moving up the food chain.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
237	PST	6531

Title: Harvesting Water from the Air: Optimization of a Novel Energy-Efficient Atmospheric Water Generator

Student Name(s): H. Tseng, H. Mebrahtu

Abstract:

Currently, more than 4 billion people are suffering from water scarcity due to global challenges, including poverty and climate change. Atmospheric water generators (AWGs) offer a viable solution due to their location-independent characteristic, which leverages atmospheric vapor condensation. However, many proposed designs are inaccessible in low-income areas because they are energy-intensive and expensive to manufacture and transport. Our project aims to leverage geothermal cooling to design a simple, low-cost AWG that can be adopted in local environments.

We constructed multiple prototypes in which a fan drew humid air through pipes of various diameters made of copper coil, connected to a fan that directed air across its surface. As air passed through, water vapor condensed on its surface and was directed into a collection container. Due to environmental constraints, the device was placed in the snow in order to provide a naturally cold environment for condensation, simulating the cooling effect that would otherwise be achieved underground. The surrounding temperature was above 0°C, while the dew point was 0°C on average.

After 24 hours of running the prototype, the 0.2” diameter copper coil did not harvest a detectable volume of water, while the ⅜” and ½” diameters harvested 4.25 oz and 6.1 oz, respectively. This data supports that increasing the diameter of the copper coil results in a larger volume of water harvested in the AWG, highlighting that larger diameters improve condensation efficiency.

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

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CSEF Official Abstract and Certification

2026

Word Count	Fair Category	Project Number
248	PST	6533

Title: Project MASTERMIND: Mobilizing Actuarial Science To Extrapolate Risk Maps Identifying Natural Disasters

Student Name(s): K. Prem, H. Venne

Abstract:

Natural disasters pose a growing threat to American society, worsened by limited public awareness of risk. Project MASTERMIND provides an online map resource offering mathematical predictions of natural disaster risk in all applicable counties of the United States, spreading awareness to individuals about their region's exposure to hazards. The maps follow trends related to climate change–a phenomenon which intensifies natural disasters across the country. Determined risk values follow expected patterns for counties, from factors like geography, social vulnerability, and community resilience—calculated using data from the Federal Emergency Management Agency (FEMA) for natural disasters. With a large amount of raw data, spreadsheets were made to efficiently calculate risk values for the counties. The calculations were completed by multiplying CRF (community risk factor) by EAL (expected annual loss) of counties, later stabilizing these values on a percentage scale. FEMA provided the EAL, while CRF was calculated by mapping the data to a triangular distribution to prioritize EAL, using transform matrices. The values produced 18 different natural disaster risk maps for 3 time periods: 2020, 2025, and 2030. Maps displaying future risk predictions use extrapolated data from prior years through logistic growth modeling. While other environmental factors could sway the predictive 2030 map set, these are authentic to current knowledge of natural disaster risks. Other maps, like those from FEMA, do not present past maps nor predictive maps for the future to the public. Instead, Project MASTERMIND's website contains 54 maps displaying past, present, and future evaluated risk data.

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

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