



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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|---|---------------------------------------|
| Name(s) David Agdashian | Project Number S1901 |
| Project Title Lightweight Radioactive Shielding | |
| Abstract Objectives/Goals The purpose of this project is to find the optimal, lightweight, yet effective shield from radioactivity. This material should be light enough to be used in rescue vehicles that the military may use in case of radioactive fallout. Methods/Materials Using a Spechttech 360 Geiger Counter, absorbers of lead, aluminum, steel, kevlar, water, and glass. Radioactive sources of Co60 (gamma), and Sr90 (beta), were used. Results The general curve is that the denser the material is the better a shield it makes. Lead was the best absorber and it was the densest material used. Conclusions/Discussion As far as absorption, lead was the best absorber because it was the most dense. The more the particles or waves need to travel through an absorber, the less strength they will have. However, based on the objective of this project, lead is not light enough to be used in vehicles, it is not practical to use such heavy materials. | |
| Summary Statement The purpose of this project is to find the optimal, lightweight, yet effective shield from radioactivity. | |
| Help Received Worked at Seebach Physics and Chemistry lab at Ribet Academy. | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Joshua M. Arreola | Project Number S1902 |
| Project Title On the Verge of Solar Success! Phase II of Creating the Most Efficient Solar Collector | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals In 2008, my goal was to determine the optimum material to place inside of a solar collector in order to maximize the collector's energy efficiency. This year, I first validated the results of my previous experiment by retesting all of the materials along with an additional material. The main objective this year was to determine if placing various reflective materials near the collector would further maximize its efficiency.</p> <p>Methods/Materials Five identical solar collectors were constructed using cardboard boxes, black paint, flexible black tubing, and glass. The collectors were each filled with soil. Four of the collectors were then placed on a 45 degree angle support and pointed away from the sun, while the last collector was placed towards the sun. This collector was the first control variable. A frame support to hold mirrors, aluminum foil, and sheet metal flashing was placed parallel to the angle support holding the solar collectors. These reflective materials were pointed at the sun and reflected the light on three of the collectors. The other collector without any reflective material being shined upon it was another control variable. The inside temperature of the panels was measured with a thermocouple. Then the temperature of the water was measured with a digital thermometer before and after it went into the collectors. The water was left in each collector for ten minutes with a total of seven trials being conducted for each collector.</p> <p>Results The overall results showed that the mirrors were the greatest reflective material to maximize the collector's efficiency, followed by the sheet metal flashing, and finally the aluminum foil. The control facing towards the sun turned out to be the most efficient, while the control facing away from the sun was the least efficient.</p> <p>Conclusions/Discussion My results show that my hypothesis was correct. I found that placing reflective materials near a solar collector has the potential of greatly improving its efficiency, even when the sun is not pointing directly at the collector. For future experiments, I will further try to maximize the collector's efficiency by adding the reflective materials on to the actual collectors themselves, essentially imitating a solar oven. This experiment can help scientists and consumers by creating an energy and cost-efficient way to provide warm water to homes.</p> | |
| Summary Statement This experiment was conducted to continue my research on solar collectors in order to discover different techniques to maximize their energy and cost-efficiency. | |
| Help Received Mom assisted with purchasing the materials, taking pictures, taking the readings, and pasting some of my board. Dad advised on how to construct the frame support that holds my reflective materials. I received mentoring from Dr. Bryan Hallmark, and from my Biology teacher, Mr. Barry Lindaman. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Onnig J. Ashikian | Project Number S1903 |
| Project Title Air Pressure Efficiency | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Problem: can using more air pressure in an air resevoir change the level of efficiency?</p> <p>Methods/Materials Materials: 1. 1 DC Generator; 2. 1 compressed air tanks (each at a different psi level); 3. 1 voltage meter; 4. 5 LED lights; 5. Conductible wires; 6. Alligator clamps; 7. 1 stopwatches; 8. Pencil and paper; 9. Ruler and calculator; 10. Pressure gauge. Procedure: 1. Gather your materials. 2. Attach the LED lights to the Generator using the conductible wires 3. Next attach amp meter and voltage meter to generator 4. Then attach compressed air tank with an initial pressure of 80 psi to the generator. 5. Next open valve for compressed air tank and keep at a working pressure of 20 psi and record amps and volts every ten seconds for one minute. 6. Repeat three times then refill tank and test it with 140 psi. 7. Finally, multiply the amps to volts and find your practical energy.</p> <p>Results In our results we discovered that the lower the psi level is the efficiency will be. This happens because when you use a higher psi level, there is going to be a lot of loss of energy. If you use less psi then you will have more efficiency and you will gain more energy because you have less losses. Although our hypothesis was wrong, we still agree because when you look at the results, the answer is clear.</p> <p>Conclusions/Discussion Eventually we had discovered that our hypothesis was wrong. In the results shown if you use less psi then you will have a higher efficiency. In our results we found out that when you use less psi, you can gain approximately 30% more energy as when you use a higher psi level. This happens because with lower psi level less energy will be lost.</p> | |
| Summary Statement I am testing whether using a higher pressure in the air tank will give a higher efficiency | |
| Help Received Father helped me with lab equipment and procedure | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Jeremy J. Blalock | Project Number S1904 |
| Project Title The Potential for Electroactive Polymers as Actuators in a Reflected Light Display Based on Cuttlefish Skin Behavior | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The project's goal was aimed to show the feasibility and potential for a digital display that relied solely upon an electrically actuated or induced change in area of some kind. In a cuttlefish's skin, micro-scale pigment cells are expanded and contracted by string-like muscle tissues, and by this change in surface area are more or less visible.</p> <p>Methods/Materials While at first the method through which this could be achieved was not clear, electroactive polymers (EAPs) were found to fit the mold very well, and so two types of EAPs were investigated to be used as actuators in such a system. Dielectric EAPs work as compliant capacitors, and produce a force in the X & Y directions when a sizable electrical force is applied in the Z direction. The tests devised to test changes in sample width, used rods instead of plates to come in contact with the sample. The material used was a commercially available tape product known for its exceptional ability to be deformed in similar ways in other applications. The first of the two physical tests used a mechanical force, applied to the sample, and visually recorded the resulting sample width using a precise manually focused camera. The second test applied an electrical force of proportional magnitude to the sample using a van de graaf generator, and visually recorded as in the first.</p> <p>Results The resulting sample width of the dielectric EAPs was shown in the experiment to increase dimensionally by ~30% when a 2N force was applied, and to closely follow a square root function, with force. Furthermore, it was shown that accordingly the change in sample width as a function of voltage followed a linear graph. Factoring in the possible sources of error that include, but are not limited to generalizations in equations and low significant digit count for actual width of sample measured in photoshop, the estimated voltage requirement would be ~40kV, which is very high, but this is being addressed.</p> <p>Conclusions/Discussion While the change in surface area from the test was only a maximum of 40%, this still makes the application of dielectric EAP materials in a reflected light display as directly expanding pixels very plausible, given initial experimental data the further experimentation will show the efficiency of the design. More research on smaller sample-sizes will continue to be done, and hopefully a more ideal voltage will be able to be used.</p> | |
| Summary Statement This project investigated a new approach to digital display technology, that in the same way cuttlefish skin does, relies on expansion and contraction of pigmented areas. | |
| Help Received Some help was received from Prof. Gamani Karunasiri, in creating a test that did not require the use of gold powdered contacts, and fabricating an acrylic casing in which to conduct the high voltage test. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Shyamal Buch | Project Number S1905 |
| Project Title "Green" Synthesis of Nanowires on FTO Substrates for Organic Dye-based Solar Cells: Analysis with New Rapid D-SCOPE 2.0 | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objectives were: (1) to synthesize nanowires on FTO substrates using environmentally benign synthesis methods, (2) to integrate these into Dye-sensitized Solar Cells (DSCs), and (3) to construct a new low-cost tool to rapidly generate DSC characteristic curves.</p> <p>Methods/Materials ZnO nanowires were synthesized on conductive FTO substrates by a sonochemical route at room ambient. A low-cost organic dye was used to sensitize the nanowires by immersion at room temperature. DSCs were assembled using these photoanodes, electrolyte, catalyst, and spacer. A new tool (D-SCOPE 2.0) was designed and programmed to generate DSC characteristic curves. From these curves, fill factor, maximum power output, and overall power-conversion efficiency was derived.</p> <p>Results ZnO nanowire DSCs achieved a higher fill factor than previously published results. Photocurrent density showed a linearly increasing trend with growth cycles. D-SCOPE 2.0 measurements occurred at rates typical of expensive laboratory equipment, at a much lower cost.</p> <p>Conclusions/Discussion Nanowire Solar Cells were successfully constructed using an end-to-end "green" synthesis method. Solar cells based on such inexpensive, environmentally benign DSCs could become a viable renewable energy source in a wide range of applications. The new D-SCOPE 2.0 enables automated measurements at a rate on par with laboratory equipment, but at a cost that is affordable by budget-constrained students.</p> | |
| Summary Statement A new low-cost nanowire solar cell was constructed using environmentally-friendly synthesis, and a new tool (D-SCOPE 2.0) was designed for rapid characterization. | |
| Help Received Sincere gratitude to Prof. M. Saif Islam at UC Davis for allowing me to use lab equipment & Mr. Nayak for supervision; to Mr. Reinking & Mr. Lempko for introducing me to robotics & programming; to Mr. Reidy for providing FTO substrates; to my family & teachers for encouragement and support. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Mark D. Canning | Project Number S1906 |
| Project Title Celestial Body Mass Estimation: A Study of the Accuracy of Using Orbital Elements to Determine the Central Body#' Mass | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals This project analyzes the variables that affect the accuracy of mass estimations using a method that relies on the relative distance and velocity of satellites of interest. The hypothesis is that the orbital eccentricity of the satellites is indirectly proportional to the accuracy of mass estimates using this method, and the accuracy of the velocity and relative distance of the satellite to the central object is directly proportional to the accuracy of mass estimates using this method.</p> <p>Methods/Materials Data for the velocities and object locations were collected from the NASA JPL HORIZONS Ephemeris. Data for the mean eccentricity of satellite orbits were obtained from NASA JPL Solar System Dynamics. The data sets included the distance and velocities of all the planets and Eris with respect to the sun, the Moon with respect to the Earth, and for Triton with respect to Neptune. A mass estimate for the central body was calculated for every point using the orbital speed equation solved for the mass of the orbital center using Excel and Maple. This was compared with modern measurements of the actual mass of the orbital center and a relative error and range of relative error were calculated. If the planets exhibiting the highest velocity and position accuracies and the lowest mean orbital eccentricity demonstrated a higher accuracy for a mass estimation, then the hypothesis would be supported.</p> <p>Results In the test of individual planets with respect to the sun, the planet that exhibited the lowest maximum relative error was Venus, at 7.097×10^{-3}, and the planet that exhibited the highest maximum was Mercury, at 4.111×10^{-1}. The overall lowest maximum relative error for any satellite was exhibited by Triton, at 3.506×10^{-5}, and the highest maximum was exhibited by Eris, at 8.869×10^{-1}. The maximum relative errors for Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and the Moon are, 1.750×10^{-2}, 9.369×10^{-2}, 4.956×10^{-2}, 1.129×10^{-1}, 5.769×10^{-2}, 1.597×10^{-2}, and 8.982×10^{-1}, respectively.</p> <p>Conclusions/Discussion The data partially supported the hypothesis. While the orbital eccentricity was almost exactly proportional to the maximum relative error for each satellite, the accuracy of measurements of the satellite's relative distance and velocity had almost no impact on the accuracy of the estimation of the mass of the orbital center, e.g., Mars and Jupiter exhibited a significantly larger maximum relative error than Neptune and Triton.</p> | |
| Summary Statement To analyze the variables that affect the accuracy of mass estimations using a method that relies on the relative distance and velocity of satellites of interest. | |
| Help Received Father helped proofread essays. | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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|---|---------------------------------------|
| Name(s) Albert C. Chen | Project Number S1907 |
| Project Title Effectiveness of Novel Natural Dyes in Dye Sensitized Solar Cells | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Dye sensitized solar cells are promising for their low cost, ability to work well in low light conditions, and absorption across the visible light spectrum. The objective is to determine the suitability of dyes extracted from rotten blackberry fruit, cranberry fruit, red globe grape peel, and soybean seed coat for use as sensitizers in dye sensitized solar cells (DSSCs) and to determine their relative performances in the solar cells. Dyes were also mixed to test for synergy of the dyes.</p> <p>Methods/Materials I made and tested my own solar cells, using ripe blackberry and ruthenium dyes as controls for comparison with literature. The appropriate fruit part was soaked in ethanol and water to make a dye sensitizer solution. A titanium dioxide semiconductor was prepared and spread on conductive glass pieces, then soaked in the prepared dye solutions. A conductive glass counter electrode was sandwiched to the photoanode, and a potassium iodide and iodine electrolyte was injected between the pieces of glass. Absorption spectra of the dyes were found with a UV/vis spectrophotometer, and open circuit voltage and short circuit current were recorded with a multimeter under various lighting setups. There were two trials.</p> <p>Results Although the theoretical power outputs were much lower than those reported in literature, the novel red globe grape, cranberry, black soybean, and rotten blackberry dyes were shown to be suitable for use in DSSCs. It was found that some dyes were more effective in low light conditions and others in high light conditions. The ripe blackberry dye outperformed the rotten blackberry dye. While there was no observed synergy overall in either of the mixed dyes, the mixed dye without the soybean dye performed better than the one with the soybean dye. The soybean dye had a different absorption spectrum from the other dyes.</p> <p>Conclusions/Discussion Lower theoretical power outputs than those in literature may be attributed to the specific assembly of the solar cells, namely the omission of an expensive platinum counter electrode. There is strong evidence supporting that the soybean dye is of a different class of natural dye than the other ones. Also, changes in chemical composition from the natural rotting process affected performance of the rotten blackberry dye. Finally, similar dyes performed better together than did different dyes.</p> | |
| Summary Statement Rotten blackberry, cranberry, grape, soybean, and mixed dyes were used as sensitizers in dye sensitized solar cells to determine the effectiveness of the dyes and study their properties. | |
| Help Received Used lab equipment in Dr. Smith's lab at San Diego State University under the supervision of graduate assistant Patrick Staley; parents helped with poster. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Jessica R. Conrad | Project Number S1908 |
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Project Title
Wi-Fi = Cancer?

Abstract

Objectives/Goals
My goal is to find out whether Wi-Fi routers increase the risk of cancer and if you can block the radiation with metal shielding, mainly copper.

Methods/Materials
An antenna, RF detector, amplifier and audio speaker were used to listen to radio frequencies coming from a MIMO and dipole router. I graphed the points on grid paper where the sound level changed from the router after placing different sheets of metal to act as shields in front of the router. I tested copper, steel, aluminum, brass, and lead shields.

Results
The signals from the dipole router were blocked best by copper, then aluminum, brass, steel and lead. For the MIMO router, the signal was not blocked, but it dissipated faster, losing strength within 6 inches with the lead shield, though the weak signal continued on.
Cell phones emit RF energy at a faster rate than routers and are used next to your head. In order to account for both factors, we must first take the max amount of absorption (1,600 mW) that cell phones can emit and reduce it by both the reduction in power and extended distance. We estimate the power reduction to be about 1/12 the original, then further reduce this due to a distance of one inch compared to 36 inches. We will do the distance reduction linearly because you are in a closed room. The reduction of power becomes (1/12) X (1/36), or 1/432 of the power at your head compared to a cell phone. The study was not specific on the SAR levels needed to raise your risk by 5%, but, if the dosage is cumulative, it will take 43,200 hours of exposure to raise your risk level 5%, but it only takes the cell phone 100 hours for the same risk level.
Assuming a person spends 4 hours a day on the computer near the router, it will take 30 years before the risk of cancer will rise 5%. This number will vary depending on the distance from the router. Extend the distance by two more feet (5 feet) and it will take 50 years before the risk rises 5%. Therefore, wireless internet does not seem to be a problem compared to cell phones.

Conclusions/Discussion
Copper worked best as a shield for Wi-Fi frequencies on the dipole router in terms of blocking the signals. A metal shield is not effective at blocking the energy from a MIMO router. Each antenna is sending a signal all around to bounce off the walls and increase coverage, and when this signal bounces back it creates coverage in front of the shield again, though weaker.

Summary Statement
My project was about whether Wi-Fi signals emitted from routers are dangerous and whether they can be blocked with metal shielding.

Help Received
Engineer Bruce Erikson gave me the equipment; Dad helped supervise the experiment ; Mom helped me glue the board together; Mrs. O'Donnell proofread my report



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Jared N. Copher | Project Number S1909 |
| Project Title Thermal Conductivity of Roof Colors | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals My experiment will answer what is the relationship between roof color and interior temperature of a house. Environmental experiments show the world at large what is wrong and then purposes how to fix it. Real hard statistics and evidence is needed to fully explain to people the severity of the threats the environment is facing and how easy it can be to fix. One good example is how black roofs absorb most of the visible electromagnetic radiation given off by the sun, one by one heating the earth. Whereas a white roof reflects all that energy away from the planet.</p> <p>Methods/Materials The experimental concept is tested on two homes crafted of thick paperboard and completely sealed off by layers of scotch tape. The scale model homes have no openings except for two windows: one in the attic and the other on the main floor of the home. The difference is that one roof is white and the other is black. The tool for measurement of temperature is the Fluke Volt/ohmmeter and temperature probe attachment.</p> <p>Results The house with a black roof does have a much higher interior and surface temperature than the home with a white roof.</p> <p>Conclusions/Discussion Black roofs absorb much more electromagnetic energy than white roofs. This energy once absorbed is turned into thermal energy on the surface of the roof and inside the home. White roofs reflect most of this energy.</p> | |
| Summary Statement My experiment will compare the color of a roof to the interior temperature of the home, and what that might mean for the environment. | |
| Help Received My advisor provided advise and encouragement. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Zoe E. Dubrow | Project Number S1910 |
| Project Title Characterization and Optimization of the Bonding Forces of a Novel Silicon Nanowire Gecko Biomimetic Adhesive | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The method by which geckos climb smooth vertical walls confounded scientists for over 100 years, until the discovery in 2000, that gecko feet are coated with millions of tiny hairs several nanometers in diameter. When a gecko foot is pressed to a surface the pliability of the tiny hairs permits them to draw close enough to the opposing surface to activate intermolecular bonding forces, allowing the gecko to adhere. In this project the bonding properties of a silicon nano-wire biomimetic gecko adhesives were characterized and its bonding forces optimized.</p> <p>Methods/Materials In this project five sets of experiments were completed in order to: Determine the impact of moisture on the adhesion mechanisms of a gecko setae mimicking silicon nano-wire surface. Discover if there is a correlation between the adhesion strength of silicon nano-wires and the surface energy of the opposing substrate. Determine if the adhesion of a silicon nano-wire covered surface to biological surfaces is sufficient for use in medical applications. Investigate the reusability of the nano-wire surface. Become the first human to hang on a wall using a nano-fiber based dry adhesive.</p> <p>Results It was found that capillarity forces caused by water evaporating off of the silicon nano-wires increased adhesion force by a factor of almost 7x compared to applying the nano-wire surface dry. It was also determined that as the contact angle of a surface increases, the strength of adhesion to the silicon nano-wire surface decreases. On a smooth wetted low contact angle glass surface, adhesion forces above 10 N/cm² were measured, greater than the adhesive force of most geckos. Adhesion forces of the silicon nano-wires to biological surfaces such as cow intestine and pig skin were found to be high enough to fail cohesively.</p> <p>Conclusions/Discussion Silicon Nano-wire surfaces can adhere to biological samples with forces high enough to cause cohesive failure of the tissue, making medical applications for targeted drug delivery or bandages and clamps that stick to moist biological tissue feasible. Also, based on optimized bonding conditions determined during the course of this study, the first documented suspension of a human from a vertical wall using nano-fiber adhesion was successfully demonstrated.</p> | |
| Summary Statement In this project the bonding properties of a silicon nano-wire biomimetic gecko adhesives were characterized and its bonding forces optimized in order to determine the feasibility of the surfaces use in medical applications. | |
| Help Received Nanosys, Inc. provided materials and equipment ; Dr. Hugh Daniels and Dr. Wally Parce gave advice | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Michael J. Feldman | Project Number S1911 |
| Project Title Factors Affecting Gas Diffusion | |
| Abstract Objectives/Goals My objective was to determine how atomic radii, atomic masses, and container shapes affect the time for two separate gases to become a homogeneous mixture and to explore the effectiveness of computer simulation methods. Methods/Materials Processing, a Java-based programming language, was used to simulate a two-dimensional model of gas diffusion under different conditions. Three separate experiments were conducted, with variation of (1) atomic radii, (2) the atomic mass ratio, and (3) the container shape. For each test, 120 repetitions were completed using different random number seeds, and 95% confidence intervals were constructed for the mean time for the gas mixture to become homogeneous. Results The time for the mixture to become homogeneous increased significantly when atoms had a higher mass. Homogeneity time decreased when the atomic radii were reduced. When the gases were mixed in containers with the same area but different shapes, the time for the mixture to become homogeneous increased in the following order: the skinny rectangle, the circular container, the square container, the thick rectangle, and finally the dumbbell shaped container. These results are statistically significant at a 95% confidence level. Conclusions/Discussion The computer simulation is an effective and powerful method in investigating how atomic interactions produce the macroscopic effect of diffusion. It allows one to study the effect of a single parameter (e.g., atomic mass) while holding all other parameters perfectly fixed, which is impossible in a lab situation. When the atomic radii decreased, atoms collide less frequently and the time to achieve homogeneity is reduced. If the mass of atoms in a type of gas increases, the average velocity must decrease if temperature is held constant. The heavier atoms therefore have smaller velocities and the diffusion process is slower. Corners tend to trap atoms and slow diffusion. Changing container shape from a square to a circle eliminates corners, making it easier for an atom to move from the edge of the container to the interior. I am currently expanding my project to simulate diffusion of radon gas through a porous material such as sandstone or shale; this is a concern for some homes in Santa Barbara. | |
| Summary Statement Investigation of how atomic masses, atomic radii, and shape of the container affect the time it takes for two separate gases to become a homogeneous mixture. | |
| Help Received Discussed project with Professor Richman twice for 1.5 hours and received references from him; Consulted parents and sister regarding showboard | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) <p align="center">Casey L. Fu</p> | Project Number <p align="center">S1912</p> |
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Project Title
Minimizing Energy Consumption under Different Force Fields

Abstract

Objectives/Goals
Force fields affect the work needed for an object to travel between two points in space. In this project, a particle traveled under the influence of five force fields (shown below) with only an engine force $r(\text{engine})(t)$ controlling its path. The purpose of this project was to determine how to minimize the energy consumed by the engine as the particle traveled from the origin to an endpoint.

- 1) Earth's gravity only
- 2) Earth's gravity and air friction
- 3) Earth's gravity and a wind force
- 4) Gravity with two planets
- 5) Custom force field

Methods/Materials
The particle was a point mass of 800 kg. Three endpoints (500, 500, 500), (7500, 800, 600), and (90000, 60000, 40000) (meters) were selected. $r(\text{field})(t)$ denotes the force field, and $r(t)$ denotes the particle's path. $r(\text{engine})(t)$ was calculated by subtracting $r(\text{field})(t)$ from $800r''(t)$. For each endpoint in each field, about ten paths $r(t)$ were selected. The paths involved constant velocity (control), polynomial, trigonometric, and exponential functions of t , and $t(\text{final})$ had values between 10 and 1000 seconds. Using Mathematica, the total energy was calculated by adding the initial kinetic energy to the work integral $W = \int_0^{t(\text{final})} r(\text{engine})(t) \cdot dr'(t)$.

Results
Energy was decreased for longer traveling times for all force fields. Trigonometric and exponential functions tended to produce significantly high energies. Under Force Fields 1, 2 and 3, a quadratic function of t with a negative leading term decreased energy. In Force Fields 4 and 5, several third degree polynomial paths with a negative leading term required less energy than using constant velocity. In Force Field 5, using a quartic term produced high energy, but using an appropriate sine wave and combining it with a linear or quadratic term can make the path more energy-efficient than the control.

Conclusions/Discussion
All the force fields showed that under the same traveling time, an appropriate deceleration from the beginning of the particle's path required less energy than traveling at a constant velocity, which required less energy than high acceleration. The use of work integrals and kinetic energy in modeling the total energy consumption under several forces is essential in finding the minimal fuel required for a vehicle traveling between destinations. This may motivate newer methods of flying aircraft or generating electric

Summary Statement
Mathematica was used to calculate the total energy required for a particle to travel from the origin to three different endpoints under five different force fields for a variety of paths, and the paths that minimized energy were determined.

Help Received
Math teacher Mrs. Brown, physics teacher Mr. Harvie, advisor Mrs. Newman, and UCSD Physics professor Dr. David Brown helped explain concepts used in the project. Mother helped glue board and make Excel charts.



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Reubin George | Project Number S1913 |
| Project Title Focusing Sound Using Non-Linear Acoustics | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals We have managed to focus light, microwaves etc. Now we reach a new goal, a way to focus sound. In general, most if not all loudspeakers invented use magnets, which vibrate by using the piston movement to change the air pressure. The main flaw with this design is that a high amplitude is need to transmit the sound over long distances. Therefore, the people who don't want to listen to the sound are greatly disturbed. The objective is to reduce the range of sound, while keeping the volume constant and directing sound in one direction.</p> <p>Methods/Materials The basic idea is to use the method of destructive interference. If two sound waves interact in a destructive interference with frequencies of 21 Hz and 20 Hz respectively, a new frequency of 1Hz is created. Although mathematically speaking a frequency of 1 Hz must be created, the laws of friction between air molecules state that the energy of the original wave must be lost as heat. What would actually be produced would be much lower than 1 Hz. But if one were to use ultrasound instead of regular frequency the energy lost as heat would be insignificant to the energy that the wave already possesses. So if 30 kHz and 40 kHz waves were to interact a new frequency of 10 kHz is created. Ultrasound is very directed in nature so the new frequency produced gets the direction of ultrasound.</p> <p>Results Ultrasound is created by piezoelectric ceramic. The ceramics use electricity very efficiently and have very little resistance. The ceramics are therefore highly effective. One creates the device using 196 piezoelectric ceramics and divides that into two groups. One group creates one frequency while the other group creates another, thus only one difference frequency was created. If one could program better one could probably create complex frequencies of music.</p> <p>Conclusions/Discussion The device worked fine. One made two people, one standing in front of the speaker and the other beside the speaker. Only the person in front of the speaker could hear the difference frequency. The sound disappeared after a range of 3.5 meters and in this range the volume remained constant. The direction was very precise and was very close to the simulation created in MATHLAB.</p> | |
| Summary Statement Focusing sound in a very specific direction using destructive interference and non linearity in air. | |
| Help Received The entire project was done by me without the help of anyone else | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Yasamin Haider | Project Number S1914 |
| Project Title Determining the Average Diameter of Globular Clusters | |
| Abstract Objectives/Goals As I was doing background research on globulars, I came across an article by George O. Abell that claimed, "the average linear diameter of globular clusters range from 20 to 100 parsecs or more". I also found a book and method by Ashman and Zepf that supported that claim. I think that the range of the claim should be changed. My instructor, Jeff Adkins, helped me come up with a new method in which I could find the average diameter of globulars. Methods/Materials I found the known distnaces from a list found by william E. Harris. I used Simbad and Aladin Online to obtain the image. Then I used Image J to find the diameter. Then, using the equation I came up with, $d=r*\tan E$, where r is the distance in parsecs. Results I then conducted my own tests and found 18 out of 20 points that demonstared my hypothesis correct. I think that the range of which the claim was made should be changed. Conclusions/Discussion There are globulars whith average diameters less than 20 parsecs. | |
| Summary Statement Finding the average diameter of globular clusters using a whole new mathematical method I came up with. | |
| Help Received From my instructor | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Taylor G. Johnson | Project Number S1915 |
| Project Title Effect of Light Pollution on the Visibility of Stars | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The visibility of stars is largely affected by the amount of light pollution in the area. Some stars remain visible everywhere you go while others appear rarely. I wanted to determine how different amounts of light pollution would affect the visibility of the stars.</p> <p>Methods/Materials In all eight experiments I used the Limiting Magnitude scale provided by the Great World Wide Star Count. http://www.windows.ucar.edu/citizen_science/starcount/. It took place on October 9-23, 2009, and people from all over the world used the following scale in order to record the visibility of stars. Basically it works like this: Depending on the number of stars you can see, you can find the approximate limiting magnitude of the night sky, meaning that all the stars you can see should at least have this magnitude. Although I attempted to use a Light Meter and a camera in order to determine the exact amount of light pollution in the area, both options failed due to the lack of light. Basically there was not enough light in the area for them to read it</p> <p>Results I compared the limited magnitudes (LM) at four spots with different amounts of light pollution. I also went to the same spot at the four phases of the moon and compared the limited magnitude of the stars. Through my experiment I found that the visibility of stars remained almost constantly at about 2.5 LM during all four phases of the moon. I also found that the stars were least visible at my house (2.3 LM), about the same at both the school and beach (2.5 LM), and was the most visible in the mountains (3.0 LM). The distance stars are from Earth and their locations in the sky can play a role in the results. For example, certain stars are not visible no matter where you are or their magnitude because they are so far away from the Earth. Finally, I discovered the phases of the moon don't affect the visibility of the stars especially if you are in a place that has a lot of light pollution already.</p> <p>Conclusions/Discussion Although I was originally correct in assuming that the less light pollution in the area from the Earth, the more visible the stars, I was also wrong in assuming that the phase of the moon largely affected the visibility of the stars.</p> | |
| Summary Statement In my project I wanted to determine how different amounts of light pollution would affect the visibility of the stars. | |
| Help Received Father drove me around and assisted in looking at the stars; Joanna Tichauer, a professional photographer and my neighbor, helped me by providing me with a camera and a light meter, as well as assisting me in using Photoshop on her computer; Anne Martin, an astronomer at Cornell University helped by | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Christine Lin; Shannon Willard | Project Number S1916 |
| Project Title The Effect of Molecular Mass on the Abruptness of the Vertical Interface Between Different Density Gases | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this experiment was to determine whether the abruptness of the vertical boundary between two gases with different densities is more dependent on the ratio of the densities or the magnitude of the densities of the two gases. Interfaces investigated were carbon dioxide to air and helium to air.</p> <p>Methods/Materials A plastic bag inside a plastic container was filled with the test gas. Container was upright for carbon dioxide, inverted for helium. Bag was opened to create interface with air and the gas density was measured as a function of vertical position and time. Gas density revealed percentage of each gas in the mixture at that point of the interface. Gas density was determined by measuring the speed of sound using the resonant frequency of an open pipe to determine this. The resonant frequency was measured by sweeping tone frequency into headphones held near an open plastic pipe and monitoring sound intensity with a microphone placed at the midpoint of the pipe. Concentrations measured in 12.7 cm increments from deepest point in container (0 cm) to mouth of the container (63.5 cm). Measurements conducted over 1300 seconds.</p> <p>Results The percentage of the test gas in air was recorded by position and time. The highest rate of change for helium was 1.7% per cm. The highest rate of change for carbon dioxide was 4.6% per cm. The helium concentration decreased to 50% at 0 cm at 1200 seconds and increased to 15% at 50.8 cm. The carbon dioxide concentration stayed near 100% up to the 12.7 cm point and near 0% above the 50.8 cm point for the duration of the experiment.</p> <p>Conclusions/Discussion The hypothesis was that more dense gases would maintain a more abrupt interface than less dense gases, even if the ratio of densities was smaller. The data supported this hypothesis. The densities of helium, air and carbon dioxide at STP are 0.1664 g/L, 1.205 g/L, and 1.842 g/L respectively. For helium to air, the ratio is 7.24 and for carbon dioxide to air, the ratio is 1.53. The steepest point of the carbon dioxide to air interface was almost three times steeper than the steepest point for helium. The flow of helium across the interface was also shown by the decrease in concentration over time deep in the container and the increase near the opening. The carbon dioxide concentration stayed near 100% deep in the container and 0% near the opening, showing much less flow across the interface.</p> | |
| Summary Statement This project evaluates whether the ratio of gas densities or the magnitude of gas densities is more important in the balance between buoyancy and diffusion in maintaining a vertical interface between different density gases. | |
| Help Received Father helped with construction and some graphs | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Bolun Liu; Merry Mou | Project Number S1917 |
| Project Title An Innovative Method for Observing Frustrated Total Internal Reflection (FTIR) | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Frustrated Total Internal Reflection (FTIR) is an optical phenomenon important in many practical applications. The greatest difficulty in studying FTIR is designing an apparatus to observe it. While researchers have studied FTIR with precision instruments, we did not have access to them. The goals were to design and build an apparatus to allow us to easily observe FTIR, to determine the media separation distance at which we can observe it, to establish a relationship between media separation and evanescent wave intensity, and to determine agreement with theory.</p> <p>Methods/Materials We designed and built an experimental apparatus that utilized two optical media (a water film and water droplet) to observe FTIR. An oscilloscope detects a light signal, which is used to measure changes in evanescent wave intensity, and an electrical signal, which is used to establish the time of contact between two optical media. A photosensor measures the light intensity of a laser beam that undergoes TIR in a water film on top of a prism. Above the water film is a metal tube through which water flows. As a water droplet nears the water film, FTIR will decrease the reflected light intensity. A circuit is shorted when the water droplet contacts the water film below. Using an oscilloscope and photosensor, we can measure the delay between the light signal and the electrical signal.</p> <p>Results The time difference between changes in the light and electrical signals was found to have a mean of 0.75 ms. Mathematical models were fit to the oscilloscope traces, indicating a logarithmic relationship between evanescent wave intensity and media separation.</p> <p>Conclusions/Discussion We successfully observed FTIR. Our estimate of the distance at which FTIR is first observable, 15 nm, is in qualitative agreement with relevant theory. Experimental limitations may explain the difference between our results and theoretical expectations for evanescent wave intensity as a function of media separation. Further studies should consider instrumentation sensitivities and photodiode and signal conditioning circuits to improve signal fidelity to establish a relationship between evanescent wave intensity and media separation. Our apparatus provides sufficient precision to detect the delay between optical and electrical signals that allow the observation of FTIR. The use of two water media to observe FTIR is an innovative idea worthy of further study.</p> | |
| Summary Statement An innovative method for observing Frustrated Total Internal Reflection was successfully developed and demonstrated. | |
| Help Received Dr. John C. Howe and Dr. Charles Barker were mentors; Intel COSMOS Research Grant funded effort; Dr. Jianxun Mou assisted in apparatus construction | |



CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

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| Name(s) Nathan J. Manohar | Project Number S1918 |
| Project Title Calculation of Atomic Energies Using Mathematica | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this experiment was to calculate the energies of the hydrogen atom, the helium ion He⁺, doubly ionized lithium Li²⁺, and the helium atom and to determine the most accurate wave function for the different atoms using Mathematica. The energies were computed using trial wave functions and minimizing the energy with respect to the parameters of the trial wave functions. These energies give information about the interactions between the electron and the nucleus and also give the ionization energy of the atom.</p> <p>Methods/Materials The energy of the atom was expressed as a volume integral of the wave function and its derivatives. Then, a trial wave function with a few adjustable parameters was chosen. Using Mathematica, the integral expression for the energy based on the trial wave function was minimized by adjusting the parameters. The trial wave function that gave the lowest energy was the closest to the actual wave function.</p> <p>Results The energies of the hydrogen atom, the helium ion He⁺, doubly ionized lithium Li²⁺, and the helium atom were computed using the variational method. When $\psi(r) = e^{-ar}$ was used as a trial wave function, the minimum energy was -1 Rydbergs when $a = 1$. This calculation gives an ionization energy for hydrogen of 1 Rydberg or 1312.75 kJ/mol, which agrees very well with the measured value of 1312 kJ/mol. The energy of He⁺ was found to be -4 Rydbergs, and of Li²⁺ to be -9 Rydbergs. The helium atom energy was found to be -5.70 Rydbergs. The helium atom computation was considerably more complicated than the one for the hydrogen atom because there are two electrons in this atom. The Li⁺ ion also is a two electron system. The energy of this ion was found to be -14.4453 Rydbergs.</p> <p>Conclusions/Discussion The numerical variational method gives accurate results for the energies of the atoms studied. The ionization energies of the atoms studied were in good agreement with the experimentally measured values. The variational method gives a very accurate determination of the energies of atoms and of their ionization potentials. In the one electron systems, the atomic energies calculated were identical to the theoretical values. For the two electron systems, the atomic energies calculated were in very good agreement with the theoretical values, but did not match them exactly due to the fact none of the trial wavefunctions used were the exact solution for the wavefunction.</p> | |
| Summary Statement The atomic energies of atoms were computed in Mathematica using the variational principle method. | |
| Help Received My father provided the references on the variational method. | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Mikael H. Matossian | Project Number S1919 |
| Project Title The Physics of Operating Compact Fluorescent Lamps | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective of my science project was to study the physics of the operation of a compact fluorescent lamp (CFL); specifically why the light output of a CFL is affected by temperature and why the light output is non-uniform along its length. My hypothesis was that the light output and non-uniformity are the result of non-uniform Hg vapor pressure due to temperature variations along the length of the lamp.</p> <p>Methods/Materials A two inch diameter, eight inch long CFL was used to test my hypothesis. The lamp was detached from its ballast electronics and mounted separately in an isothermal Styrofoam enclosure to remove any temperature effects of the ballast electronics from the performance of the Hg-filled lamp. A solar cell mounted to the wall of the enclosure was used to measure the light output of the lamp. The temperature of the lamp was measured at three locations along its length; at the base, the midpoint, and tip. Correlations were made between lamp temperature, lamp light output, and electrical power.</p> <p>Results</p> <ol style="list-style-type: none">1. The light output of a CFL increases to a maximum of 50% above the initial turn-on light level and then decreases by 20% below the maximum light level at a steady state.2. The lamp temperature continuously increases until steady state is reached. At equilibrium, there is a 60 °C temperature gradient between the base and tip.3. The increase in light output before the maximum is reached, correlates with increased Hg vapor pressure that follows the Clausius-Clapeyron equation.4. The decrease in light output after the maximum is reached, correlates with UV radiation trapping by Hg vapor. <p>Conclusions/Discussion A compact fluorescent lamp does not operate at its maximum light output. The non-uniform temperature distribution along the length of a CFL is due in part of a hot filament at the base of the lamp. The Clausius-Clapeyron equation accounts for the initial increase in light output after lamp turn on, while mercury radiation trapping is responsible for the light output maximum and subsequent decrease.</p> | |
| Summary Statement The operation and light output of a compact fluorescent lamp is strongly influenced by the properties of mercury vapor. | |
| Help Received My father greatly helped with the general assembly of the entire project, acquiring parts, and in data measurements. The CSUN Oviatt Library staff allowed me to use their databases and helped me find a number of articles from which I got ideas for my project. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Jackson D. McKay | Project Number S1920 |
| Project Title Swingin' | |
| Abstract Objectives/Goals How will different gasses resist the motion of an object? I believe that the denser the gas is, the more it will resist the motion of an object. To test this I will have a small air tight chamber that we can pump gases into. In general, a denser gas should slow an object, as it will produce greater friction. However, some people may argue that on the pendulum's up swing, the denser gas below may allow for more lift. This isn't true, and even if it was, it would fight the same force when coming down. Methods/Materials Procedure: 1. Build a small air tight chamber made of a jar and wood base that we can evacuate gases into. The chamber must be clear so I can see into it. Inside the chamber will be an iron pendulum. 2. Place an optical motion sensor inside the chamber placed so its beam travels through a point slightly before the pendulum's rest point. Each time the pendulum passes through, it will trigger a tone so the number of swings can be counted. 3. Pump the gas in and seal the chamber. 4. Tilt the chamber on its side, the pendulum will make contact with the side, and put a magnet on the outside of the chamber to hold the pendulum in place in. Note its position in order to have a respectable and equal amount of potential energy stored in the pendulum in all tests. 5. Once the chamber is put upright and all movement has stopped, release the magnet and the pendulum will begin to swing. 6. Time how long it swings 7. Do several tests with different gasses (and a vacuum) and different pressures. Regular air will be the control. Materials: Large Glass Jar; Base Wood; Rubber; Pressure gauge; Pendulum (ferrous metal); Magnet; Optical motion sensor; Air Compressor; Plain air; Helium; Carbon Dioxide; Carbon Dioxide-Argon mix. Results The data shows a clear correlation: The denser the gas, the shorter the time that the pendulum will swing for. Conclusions/Discussion The data shows a clear correlation: The denser the gas, the shorter the time that the pendulum will swing for. | |
| Summary Statement I wanted to determine how a pendulum will swing differently in different gases. | |
| Help Received My father helped build the device, and he helped make the graphs | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Dylan E. Moore | Project Number S1921 |
| Project Title Creating and Modifying a Fuel Cell System for Clean Energy | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Fossil fuels are not a sustainable energy source and their emissions significantly degrade air quality. The greenhouse gasses they release are a leading factor in global warming. Hydrogen used in fuel cells helps contribute to a sustainable energy solution. The purpose of this project was to create a proton exchange membrane (PEM) fuel cell using readily available materials and increase its performance through structural modifications.</p> <p>Methods/Materials A membrane electrode assembly (MEA), used as the catalyst, was sandwiched between two graphite plates with channels cut to provide hydrogen and oxygen for the reaction. A multimeter was used to measure voltage and amps for each trial. The surface area of hydrogen exposed to the catalyst was varied using interchangeable plates A, B and C with surface areas of 2.6cm², 1.31cm² and 0.58cm² respectively. A modified McLeod gauge measured the pressure within the system and a valve was used to regulate the flow of hydrogen. Trial sets were run for each of the plates at 0.5mm Hg above atmospheric pressure and then at 4mm Hg. This data was used to calculate the power output of a hypothetical Plate D with a surface area of 26cm².</p> <p>Results Plates A, B and C produced 0.064W, 0.065W and 0.071W at 0.5mm Hg and 0.082W, 0.073W and 0.074W at 4mm Hg respectively. The percentage change of power from 0.5mm Hg to 4mm Hg for Plates A, B and C were 1.281%, 1.23% and 1.042% respectively, showing a greater change for larger surface areas. The graph of the percentage change in power relative to the exposed surface area for all trials revealed a linear relationship. This was used to project the percentage change of power for Plate D to be 4.06%. The power output of Plate D at 0.5mm Hg was projected to be 0.054W with the curve of best fit for the average power outputs of Plates A, B and C at 0.5mm Hg. The projected power for D was 0.219W at 4mm Hg.</p> <p>Conclusions/Discussion This project compared the power output of a PEM fuel cell to the exposed surface area of an MEA and the pressure within the fuel cell system. Trials with greater exposed surface area to hydrogen flow had greater rates of power increase with pressure in relation to the others. This indicates that pressurized systems are needed to achieve optimal performance in larger fuel cells.</p> | |
| Summary Statement This project compared how the amount of hydrogen pressure and the surface area of a membrane electrode assembly (MEA) catalyst exposed to hydrogen affect the power output of a proton exchange membrane fuel cell. | |
| Help Received I did all my research and experiments at home with parental supervision. Experiments were conducted outside for safety with at least one parent present at all times. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Lauren Y. Nguyen | Project Number S1922 |
| Project Title Optimizing Microbial Fuel Cell Output by Varying Relative Surface Area | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this research project is to optimize the output of a sediment microbial fuel cell (MFC) by varying the ratio of anode to cathode effective surface area. Sediment microbial fuel cells work by utilizing the potential difference between the anode in the biologically active mud and a cathode in the water above. The anode undergoes an anaerobic reaction; whereas, the cathode requires oxygen for its reaction. As a result, the cathode can have its effective surface area increased by oxygenating the water with an air pump, providing the required precursor for the cathode reaction. It was expected that in a 1:1 configuration, the anode would be the limiting factor due to the semi-solid transport limitations of the bacteria that must be in close proximity with the anode.</p> <p>Methods/Materials In this experiment, an initial fuel cell with a 1:1 anode to cathode ratio was constructed. Baseline measurements of voltage and current were taken with a digital multimeter. Then, MFCs were built with 2:1, 3:1, 4:1, and 6:1 ratios. The measurements taken were compared to the measurements of the initial MFC. After a baseline was established for each configuration, the effective cathode surface area was increased by oxygenating the water around the cathode.</p> <p>Results The results support a conclusion that an optimum can be reached between the effective surface areas of the anode and cathode. The 2:1 MFC seemed to produce the most voltage and current. However, worms that were indigenous to the mud started to appear in each microbial fuel cell after each cell was oxygenated. The worms, surprisingly, inhibited the fuel cell reaction as the voltage and current dropped dramatically after the air pump was removed.</p> <p>Conclusions/Discussion The unexpected appearance of mud worms in the MFC highlighted the need to consider the actual environment that the fuel cell will operate in. Before the installation of these cells in actual use, engineers need to consider and anticipate the wildlife that grow and live in the planned environment. This research project shows that MFCs can be a viable power source in the future. An effective microbial fuel cell could provide 3rd world, rural civilians with network connectivity, such as cellular and telemedicine applications. Additionally, MFCs could power long-term sensor applications for environmental monitoring and military situational awareness.</p> | |
| Summary Statement My project is about sustainable, renewable energy sources for sporadic power applications. | |
| Help Received My stepfather helped me find the materials needed to build the microbial fuel cell, and we worked together in assembling the project. | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Noah G. Shartle | Project Number S1924 |
| Project Title Chasing Michelson: Measurements of the Speed of Light in Air | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals Calaveras County is known for its gold rush, the giant sequoia, and a celebrated jumping frog. Unknown to many, however, is that Calaveras County was the childhood home of Albert Michelson, the first American to win the Nobel Prize in Physics. In an effort to call local attention to Michelson's accomplishments, I attempted to measure the speed of light in air with greater accuracy than Michelson.</p> <p>Methods/Materials The beam from a .8 mW diode laser was modulated using a 1 MHz sinusoidal wave. The modulated beam was split into a first and second portion. The first portion traveled a short distance, and was then focused onto a first photodiode. The second portion traveled a longer distance, and was then focused onto a second photodiode. Output from the photodiodes was amplified, then connected as input to a digital oscilloscope. Signal from the first photodiode was used as a trigger, and the delay time between the two sinusoidal waves was measured. The difference in distance traveled was measured, then divided by the delay time to determine the speed of light in air. Multiple measurements were made across three distances.</p> <p>Results The delay time across 6.243 meters was 19.4 nanoseconds, the delay time across 10.279 meters was 32.9 nanoseconds, and the delay time across 16.721 meters was 53.4 nanoseconds, on average. The coefficient of variation when measuring delay time across 6.243 meters was 7.36%, across 10.279 meters was 5.52%, and across 16.721 meters was 3.46%. Using these measurements, the speed of light was found to be 322,000,000 meters/sec, 312,000,000 meters/second, and 313,000,000 meters/second.</p> <p>Conclusions/Discussion The speed of light in air is 299,705,543 meters/second. Michelson's measurement of 1878 was 300,091,000 meters/second, off by + 0.13%. In my best measurement, I was off by about + 4%. Despite using modern equipment, I was unsuccessful in making measurements that are more accurate than Michelson's. In measuring the delay time between the sinusoidal waves, I found that the imprecision of the measurement decreased as the delay became longer. For this reason, taking measurements across greater distances could lead to improved precision, and accuracy. To make measurements at greater distances, a more powerful laser could be used, and the beam could be collimated, decreasing the divergence of the beam as it travels greater distances.</p> | |
| Summary Statement The goal of this study was to measure the speed of light in air with greater accuracy than Michelson. | |
| Help Received Experimentation was performed at home, with my parent's supervision. I borrowed an oscilloscope from a friend. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Rishika Singh | Project Number S1925 |
| Project Title Twinkle, Twinkle Little Star, How I Wonder How Old You Are: Exploring Stellar Evolution of the Open Cluster Population | |
| Abstract Objectives/Goals My objectives are to (1) calculate the age of Monoceros R2 by producing an H-R diagram, (2) to find a correlation between the ages of clusters in existing literature and their galactic coordinates, distance, diameter, and height. Methods/Materials (1) After obtaining an account and acquiring a time slot, access the Faulkes Telescope in order to capture images of Monoceros R2. Then, complete the photometry and produce the H-R diagram using Microsoft Excel. Conduct the same procedure for nine other clusters, three clusters from three different age groups (young, intermediate, old). Acquire the information for each cluster on the WEBDA database. Results (1) The H-R diagram for NGC 1976 (7.11 years in log age, one of the young clusters) was most alike to Monoceros R2, therefore they were of similar age. (2) Galactic latitude, longitude, and distance were insignificantly correlated with the age, as shown by the low correlation coefficient and high p-value. With the high correlation coefficient and low p-value, the diameter versus age and height versus age relationships were significantly related. Conclusions/Discussion (1) The estimated age of Monoceros R2 is 13 million years old, or 7.11 years old in log age. (2) Height and diameter were correlated with the age, while galactic longitude, latitude, and distance were not. Therefore, my hypothesis concerning distance versus age was incorrect, while the height versus age prediction was proven to be true. | |
| Summary Statement Age was calculated for the Monoceros R2 cluster and physical characteristics of open clusters were compared with their age. | |
| Help Received Parents helped with data analysis and presentation; Dr. Rachel Street and Ms. Jessica Barton (LCOGT) helped with question formulation, procedure, analysis methods, and background information, software installation, online projects, and program usage; Mrs. Kim Miller helped with background and analysis. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Chad W. Spalinger | Project Number S1926 |
| Project Title Fighting Fire with Sound | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective of the project was to determine if sound waves can extinguish a flame from a candle, what the optimal frequency and amplitude is to put the flame out, and how the distance between the flame and the sound source affects the sound level.</p> <p>Methods/Materials A cupcake with a birthday candle and a twelve-inch subwoofer were placed in an empty fish tank. The candle was lit, and a decibel meter was placed a few inches away from the subwoofer to record the sound level. A tone generator program was used on a laptop that was connected to a receiver, which was connected to the subwoofer. Tests were run in increments of 10Hz from 0-100Hz. The flame was placed at various distances from the subwoofer to find the shortest and most efficient location for the subwoofer to extinguish it. The flame was then placed in the back of the tank, twenty-one inches away from the subwoofer, and tested again.</p> <p>Results A frequency range of 40-50Hz and amplitude range of 115-126dB were optimal ranges to extinguish the flame. Six inches from the subwoofer was the shortest and most effective distance for the flame to be extinguished. Higher amplitudes had to be used in order for higher frequencies to put out the fire. The amplitude was higher when the candle was placed farther away from the subwoofer.</p> <p>Conclusions/Discussion I proved my hypothesis correct except for my statement: the closer the candle is to the subwoofer, the easier it is to extinguish. The flame had to be a certain distance away in order for the sound waves to effectively put it out. This science project is can be a beneficial engineering tool in fields of transportation and communication. Subwoofers can be installed in electrical control panels and be able to detect any fire within a reachable distance. The sound waves can successfully extinguish the flame without having to destroy the control panel with water.</p> | |
| Summary Statement My project is about using sound waves to extinguish fire and relating the difference between distance and sound level. | |
| Help Received Brother lent me his sound system. Mother helped supply me with the materials needed. | |



CALIFORNIA STATE SCIENCE FAIR 2010 PROJECT SUMMARY

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| Name(s) Brian J. Vallelunga | Project Number S1927 |
| Project Title Blowout: Acoustic Fire Extinguisher | |
| <p style="text-align: center;">Abstract</p> <p>Objectives/Goals The scientific exploration of Unconventional Fire Extinguishers is full of exciting unexpected responses. The term "Unconventional Fire Extinguisher" is used to describe an unorthodox fire extinguisher. This year's project is to extinguish the flame on a candle using acoustic energy.</p> <p>Methods/Materials The acoustic fire extinguisher is a two part apparatus. The core of the apparatus is a Goldwood GW-12PC/8 8 ohm 12 inch Woofer Speaker Driver enclosed in a casing made out of 5/8 inch plywood. Attached to the casing is an acoustic amplifier designed to increase the dynamic pressure created by the driver. A Nikko Integrated Stereo, DC Amplifier model NA - 2090 amplifies the signal generated by the MacBook Pro laptop and directs the signal to the driver. The acoustic energy generated by the apparatus works by blowing the flame off the fuel source and by creating a vacuum around the fire, suffocating the flame. The acoustic energy produced by the apparatus is sufficient to extinguish the flame on a candle at the minimal power setting of the amplifier.</p> <p>Results The result of the scientific investigation was the apparatus successfully extinguished the flame on a candle in 2-5 seconds with minimal amplifier power.</p> <p>Conclusions/Discussion The acoustic fire extinguisher has the potential to revolutionize fire suppressions systems in critical environments such as data centers and spacecraft. The acoustic fire extinguisher projects a focused stream of high velocity air at the target flame that both blows the flame off the fuel source and suffocates it. The application of this technology has the potential to save tremendous resources because it is nondestructive and requires no chemicals, solutions or dangerous substances to extinguish a fire.</p> <p>Employing advanced fire detection systems such as infrared imaging and high speed computers to detect the first sign of a fire, the automated acoustic fire extinguisher will suppress a fire at the instant it is discovered saving human life and critical resources.</p> | |
| Summary Statement This project demonstrates the viability of extinguishing the flame on a candle using acoustic energy. | |
| Help Received My father provided advise and encouragement. | |



**CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY**

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| Name(s) Matt A. West | Project Number S1928 |
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Project Title
Air Capacitor Based Oscilloscope Impedance Spectroscopy: An Effective Method for Characterizing Oil-Water Emulsions

Abstract

Objectives/Goals
Crude oil is often contaminated with water or brine when recovered from reservoirs. These oil-water emulsions can cause corrosion in pipes, posing problems such as equipment failure in refineries. The focus of the project was to evaluate the effectiveness of Air Capacitor Based Oscilloscope Impedance Spectroscopy (ACOIS) to measure the properties of oil-water emulsions in terms of dielectric constant and resistivity.

Methods/Materials
The emulsions were prepared by blending SAE 30 HD motor oil, surfactants, and various amounts of water/salt-water/acid/base. The emulsions were poured into plastic containers that have various types of metals inside. Next, an air capacitor is placed into the oil-water emulsion. Then, a function generator applies a signal across the circuit while the oscilloscope measures the applied and resultant signals. These signals are then plotted on a Lissajous graph, and the phase angle and magnitude of impedance are found. Finally, the data is then plotted as real and imaginary components of impedance, and then fitted using data fitting software.

Results
There are several key findings in my study. First, in the 3% water-oil-air emulsion additions of 0.29 weight% of salt were added sequentially, and the value for the modeled resistor decreased as a function of salt concentration, confirming the fact that ACOIS can measure a very small change in dissolved ion concentration. Second, water concentration was varied over several oil-water-air emulsions, ranging from 0 to 15% of water, and the dielectric constants for the emulsions were calculated. The increase of the dielectric constants as the % of water increases proves the point that ACOIS can detect changes in the dielectric constants of oil-water emulsions. Third, aluminum soaked in NaOH-oil emulsion exhibited a decrease in emulsion resistance after 125 days of soak time, which is a clear sign that corrosion of the aluminum alloy occurred, measured by ACOIS.

Conclusions/Discussion
From this study, it has been found that ACOIS can measure very small changes in dissolved ion concentration, and dielectric constants in varying oil water ratios. It can clearly measure instances when corrosion occurs when the corrosion products are soluble, which is evident through the Aluminum Base 10% sample. However, ACOIS cannot measure corrosion when the corrosion byproduct is insoluble. This was apparent in most steel soaked samples.

Summary Statement
By measuring the magnitude/phase angle of a circuit soaked in oil water emulsions, I calculated the real/imaginary components of impedance as a function of time, content, and metals present to determine the properties of the emulsions.

Help Received
My dad purchased the oscilloscope for me, and taught me how to make measurements. In addition my advisor Professor Ravi of Cal Poly Pomona helped me along with the project, and suggested some more specific directions to follow.