Vaughn College Journal of Engineering and Technology
April 2017

"When you catch a glimpse of your potential, that's when passion is born." Zig Ziglar

The Vaughn College Journal of Engineering and Technology (VCJET) is published annually in preparation for the Technology Day Conference. It includes events and activities of the Department of Engineering and Technology, such as faculty professional development, student engagements, robotics competitions, UAV activities, poster competitions, conference presentations, and publication of the best student research papers.

Given the rapid pace of technological change, the Journal is intended to assist Vaughn engineering students in developing a mindset that recognizes lifelong learning as necessary in order to meet future professional challenges. The ultimate aim of the Journal is to engage and prepare students for the future in engineering research and innovation. Furthermore, this Journal research project strengthens student learning outcomes related to critical thinking, problem solving, communication, and teamwork. The enhancement of these learning outcomes through engineering and engineering technology programs not only provides students with an excellent education, but also helps them develop leadership and entrepreneurial skills.

A journal paper project must be developed and investigated in such a manner that it satisfies the learning objectives of engineering education. Some of the learning objectives emphasized in the development of a technical paper are:

1. Intention plan (Abstract): Developing a proposal that outlines the details of a project and its impact on local and global society
2. Application: Identifying the use and application of the project in global society
3. Methodology: Providing a brief description of methods and solutions
4. Teamwork: Identifying team members and their responsibilities in the project's development
5. Modeling: Providing a complete and precise drawing of the project
6. Analysis: Providing all necessary analysis and analytical tools used to satisfy the system's safety and computing requirements
7. Conclusion: Discussing the result(s) and the contribution of the project to local and global society
8. Reference: Identifying research references
9. Presentation: Presenting the selected design paper in a Microsoft PowerPoint format to the industry advisory members, faculty, and other members in the audience during the Technology Day Conference

The Journal's topics include technical papers that are related to computational mechanics, solid mechanics, mechatronics, robotics, avionics, electronics, and other topics pertinent to the engineering and engineering technology fields.

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A Brief Review of Vaughn College's Eighth Annual Technology Day Conference

April 28, 2016

Vaughn students, faculty, alumni, and industry professionals convened in April 2016 for the College's Eighth Annual Technology Day Conference and Industry Advisory Council meeting. Advisory Council members were given updates on recent developments in the engineering and technology department, implementation of the new mechanical and electrical engineering programs, installation of new Energy Conversion and Power System laboratory, new 3-D Prototyping Innovation Center, new Machine Shop, enhancement of existing laboratories, success of Vaughn's Robotic team in 2016 World Championship, internships and other issues related to the engineering and engineering and technology programs. In the afternoon session, Vaughn students presented their technical research work and papers to the conference attendees.

Vaughn College's President, Dr. Sharon DeVivo, welcomed the guests and gave them an overview of the College's current and future direction. Academic Vice President, Dr. Paul LaVernge, thanked our advisory members and provided them with an insight regarding the upcoming Middle State accreditation, the self-study report and preparation for the 2017 site visit. Dr. Hossein Rahemi, Chair of the Department of Engineering and Technology, thanked the advisory members for their ongoing support and valuable feedback regarding all of the department's programs. He also updated the advisory members on student and faculty professional development, on the outstanding success of the Vaughn College Robotics Team as a 2016 VEX U Robotics World Champion, on the new mechanical and electrical engineering curriculums and the implementation process, on the participation of Vaughn's UAV team as a finalist in The American Helicopter Society (AHS) Annual Micro Air Vehicle (MAV) Student Challenge competition on May 16, 2018 at West Palm Beach, Florida, and on hosting the UAV Workshop at Vaughn College on May 7, 2016 to celebrate the International Drone Day.

Among the speakers at the conference was Mr. Jimmy Carchietta from The Cotocon Group who talked about energy management, efficiency, and smart energy consumption. Mr. Oliver Scheel from US Didactic spoke about equipment related to manufacturing and solar energy.

The Vaughn Robotics Club, UAV Club, Society of Women Engineers Club, Engineer Without Borders Club, Electronics Club, and the NSF learning community gave presentations about their annual activities and extra-curricular involvements. The Vaughn Robotics Club discussed their innovative robotics design using 3D printing parts, advanced programming for fast autonomous performance, unique lifting design to lift the partner robot and strategies that they employed to win the 2016 VEX U Tournament Champion of Design Division, World Championship title. This Vaughn club was also the recipient of both Innovate and Design awards for demonstrating ingenuity and innovation in the design of their robots which forms a solution to complex problems in the Robotics field. The UAV club presented their quadcopter design and autonomous programming before participating as a finalist in the American Helicopter Society (AHS) Annual Micro Air Vehicle (MAV) Student Challenge competition on May 16, 2018 at West Palm Beach, Florida. In this competition, Vaughn's UAV team will compete in the autonomous category with four other finalist teams from Georgia Tech, North Carolina A&T State University, North Dakota State University, and University of Maryland.

Vaughn graduating students gave presentations about their capstone research projects during the afternoon paper and poster sessions of the 2016 Technology Day Conference. The winning papers included: First place research paper winner, "Innovative Robotics Design for VEX U Challenge - Nothing But Net game" by Jefferson Maldonado, Alex Uquillas, Kent Ogisu, Terry Cetoute; second place research paper winner, "Customized Electronic Wheelchair" by Shady Abdelmalek; and third place research paper winner, "Design and Implementation of a Braille Clock" by Saneela Rabbani and Josiah D'Arrigo.

Students' Capstone Research Papers Presentation

The winning Degree Project posters included: First place poster winner, "Heated Windshield Wipers" by Kevin McConkey, Thomas Liquet, and Vincent Collucci; second place poster winner, "Air Traffic Control Mode S Receiver" by Karim Fadel, Hasan Moosavi, and

Muhammad Furqhan Ahmed. The first place NSF Learning Community poster winner is, “Designing a Universal Allen Key to Optimize Work Efficiency” by Nicholas Kumia and Bobby Tang.

Students’ NSF and Capstone Degree Posters Session

Eighth Annual Advisory Meeting and Technology Day Conference, April 28, 2016

Summer Engineering Experience (SEE) Program

The Summer Engineering Experiences, SEE Program is designed with an objective to enhance students' hands-on, computational, programming, communication, and problem solving skills. The SEE program is offered during the summer to the first year engineering students and covers topics related to engineering computation using MATLAB and C++, robotics, bridge truss design & analysis, and technical writing.

The following learning outcomes have been established to assess student performance in the Summer Engineering Experience program. These student outcomes are as follows:

(a) Students will demonstrate an ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.
(b) Students will demonstrate an ability to design and conduct experiments, as well as to analyze and interpret data with the use of computer applications current to industry;
(c) Students will demonstrate an ability to design and apply creativity in the design of engineering systems, components and process;
(d) Students will demonstrate an ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty;
(e) Students will demonstrate an ability to communicate effectively with a range of audiences
(f) Students will demonstrate an appropriate mastery of the knowledge, techniques, skills, and modern tools used in the engineering field;

Attainment of these outcomes prepares students in the SEE program for the core courses within engineering disciplines and provides them with an ability to be successful in their professional career path.

Mapping of student outcomes vs Topics in SEE Program: The mapping of student outcomes vs topics offered in SEE program were discussed and developed by the participating faculty members and is presented in Table 2.

Table 2: Relationship of Topics to Student Outcomes

Topics	a. Math, Science, Solve Engineering	b. Experiments, Computer	c. System Design, Components,	d. Function Effectively on	e. Communication	f. Techniques, skills, and modern tools
Truss Bridge Design and Analysis	•	•	•			
Computational Method with MATLAB	•	•				•
Computational Method with C++	•	•				•
Statics	•					
Robotics		•	•	•		
Technical Writing and Presentation				•	•	

Computational Method with MATLAB and C++ Application

This topic in the SEE program provided students with some fundamental knowledge of engineering analysis and programming using both MATLAB and C++. Students were introduced to topics such as Taylor Series, finite difference, root determination, and numerical integration with application to engineering problems. Both MATLAB and C++ were introduced to students as a computing tool to generate results and facilitate the process of investigating behavior in an engineering system. Through both computational and programming (MATLAB and C++) sessions, students were introduced to the following computational processes

- Mathematical governing equation of an engineering system
- Development process of an analytical and numerical formulation
- MATLAB and C++ Programming
  - How to work in MATLAB and C++ environment?
  - How to use logical control loops?
  - How to write a MATLAB and C++ program?
- Development process of closed-form and numerical solution of an engineering system

Figure 1 is a graphical representation of this computational project based learning.

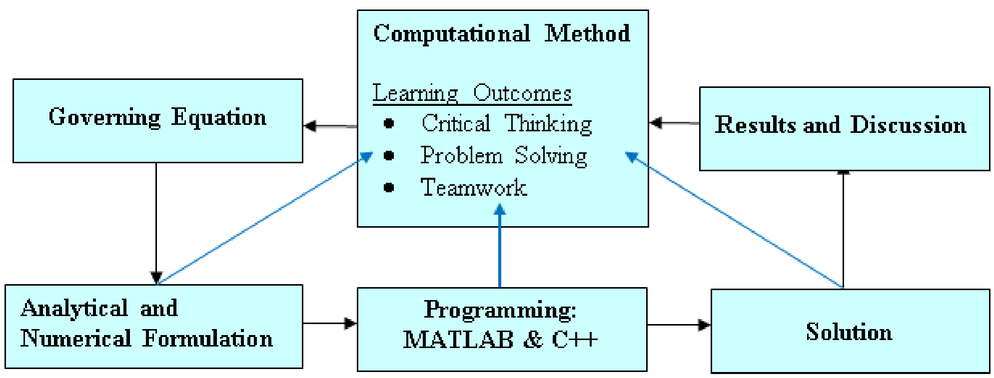


Figure 1: A graphical model of computational project-based learning

In the first two weeks (Two hours per day for four days per week) students were introduced to both MATLAB and C++ programming and how to use logical control loops such as for loop, while loop, conditional loop, switch, and function to develop programs for specific application. In the third and fourth weeks students learned how to write a program with application to engineering problems related to root determination, numerical integration, beam deformation analysis, impulsive vibration, and numerical analysis of a governing engineering equation. In the last week, students worked with faculty mentors and developed a project titled "Computational Methods of Analysis Using C++ and MATLAB" and presented their work to faculty and the Vaughn community on the last day of the summer session. Their projects were assessed by faculty members according to the following learning outcomes

- Students will demonstrate an appropriate mastery of the knowledge, techniques, skills, and modern tools used in the engineering field – Both MATLAB and C++ are used as a programming and computational tool to solve analytical and numerical solution of an engineering system.

- Students will demonstrate an ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics – Both the analytical and the numerical form of an engineering governing equation require knowledge of mathematics and engineering principles.
- Students will demonstrate an ability to communicate effectively with a range of audiences – Projects require both report writing and presentation.

Robotics and autonomies programming

In order to enhance freshman students' engineering experience, the robot design and implementation were considered an important part of the summer program. The course objectives were to help students understand engineering design, implementation and the troubleshooting process using the practical platform -- VEX Educational Robots (EDR).

Students for this session were involved with engineering design and development, understanding DC motors and the relationship between the speed, power and torque, as well as concurrent use of a variety of sensors in robot programming using RobotC and VEX Cortex controller. Upon the completion of the class, students demonstrated knowledge of the engineering design process and had the ability to complete a project. They were, for example, able to build and to program a mobile robot using VEX robotic parts, different types of sensors as well as 3D printing parts. The activities of the course covered the following topics:

1. Introduction to engineering, team work, design process and design documents.
2. Discussion of DC motors as well as speed, power and torque limitations under the requirements of load and speed.
3. VEX Cortex controller as well as programming DC motors and sensors.
4. Program structure review and existing program analysis.
5. Robotic project design, implementation and trouble shooting.
6. Presentation of the robotic project.

During their five weeks of classes with four days per week and one hour per day, students learned step by step about the above subjects. In the first five weeks, their homework assignments included the development of engineering design concepts as well as robot programming to complete a sequence of tasks using a variety of sensors. In addition, three quizzes were given to examine students' learning outcomes.

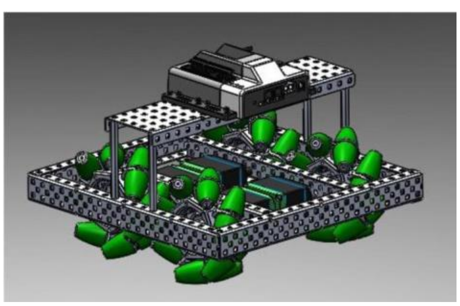


Figure 2: Robotic Chassis with Motor Mecanum Drive

By the end of the class, students selected a project titled Robotics and SEE Program. In the project, students built a robotic chassis with four motor mecanum drives as shown in Figure 2. On the chassis, six different sensors were installed. They are one encoder, one ultrasonic sensor, two line tracking sensors, one limit switch, five bump sensors and one potentiometer. A speaker module is also installed. The VEX Cortex controller was programmed to explore the possibility of developing sensor redundancy, i.e. when an object is captured, the correct result will be derived from the measured results from a number of sensors and the speaker will remind the designer which sensor(s) may have a problem.

Bridge Truss Design and Analysis

This session of SEE program introduced students to some basic concepts used in solid mechanics along with simple design and hands-on application.

During this session, students were given an introduction to basic concepts such as stress, strain, deformation, and Hooke's law. Applications of these concepts were then introduced to students in which they studied and analyzed a basic Warren truss bridge. Students were given an opportunity to design and build a simple Warren truss bridge which was required to support the load of a truck driving over it. During this design process, students used software such as excel and CATIA. As part of the class, students were also required to write a short report explaining their design process and build a small bridge based on their design. Figure 3 shows the bridge designed by students using CATIA.

Figure 3: CATIA design of a Warren truss bridge

In the last day of summer session, students presented their project titled "Bridge Design and Analysis – Hands-on, Project-based learning" to faculty. Their project was assessed according to specific student learning outcomes.

Technical Writing and Presentation

This program addressed the technical writing needs of students in engineering, such as using plain language and clear word order and reducing ambiguous terminology. Students completed daily exercises covering many stylistic aspects of engineering writing, and they practiced the expression of technical knowledge in a concise and effective manner.

The program culminated with several group presentations, and in preparation for these public talks, students learned how to tell effectively the story of their work. After practicing their presentations in front of their classmates, they then made adjustments to their exhibitions based on the observations and comments they received.

Assessment: Students' Evaluation of SEE Program

As an indirect measure, a rubric survey based on the contents of SEE programs is given to students in order to assess the effectiveness of the SEE programs. Table 3 below provides the results of these evaluations.

TABLE 3: SURVEY'S RESULT AND ANALYSIS

Questions	Response in percent of participants (Number of participants: 5)			
	Poor	Fair	Good	Excellent
1. Rate SEE program in preparing you with the applied computational, design, & programming.			40%	60%
2. Professor's ability in introducing you to MATLAB programing and application				100%
3. Professor's ability in introducing you to C++ programing and application				100%
4. Professor's ability in introducing you to robotics and autonomous programing		20%	20%	60%
5. Professor's ability in introducing you to bridge design and analysis			20%	80%
6. Professor's ability in introducing you to technical writing and presentation		20%	40%	40%
7. Rate SEE program in providing you with skills in problem solving, communication, and teamwork.			20%	80%
8. Rate SEE program in providing you with adequate knowledge and skills for your program of study.			40%	60%
Overall average Learning Outcome Attainment		**8%**	**36%**	**56%**

The survey results and student comments are an indication that the SEE program has been satisfactory and provided students with a profound appreciation for engineering education. Overall, 56 percent of the survey participants rated the SEE program as excellent and 36 percent rated their instruction as good.

Below are students' comments regarding SEE program

- The SEE Program was an excellent opportunity for me to gain some insight as to what I can expect when working post-graduation. I learned the practical applications of things, as well as how to apply them. I would recommend the SEE Program to all freshman students, as it also prepares them for future classes.
- This program helped me to understand applications of engineering principles in bridge design, robotics as well as engineering computation. Also, the programming skills that I learned through the SEE program provided me with the knowledge in analyzing behavior of an engineering system. Certainly, I do recommend this program for all freshmen who are entering in an engineering program.
- The SEE program was very rewarding; it gave me a background of what I will be studying in the upcoming future. I do recommend it for all freshman students.
- I felt that the program was very beneficial for me personally, because it offered experience in classes that I had not taken yet that were critical for engineering. As a graduate of the program I would recommend that the program be offered to freshman students who are interested.

Friday's Seminars and Workshops

Friday's session of SEE program is designated for technical seminars and workshops. This session is designed to enhance students' learning outcomes related to critical thinking, problem solving, and life-long learning. Given the rapid pace of technological change, the Friday's seminar series and workshop will help our students in SEE program to develop a mind-set receptive to changes in technology and will prepare them for future challenges.

Seminar #1
Date: Friday, June 3, 2016, 10 am -12 pm
Presenter: Mr. Johnathan Sypeck, Ph.D. Student at City College, CUNY
Topic: Academic Success

In this session, Mr. Jonathan Sypeck, an outstanding Vaughn alumnus and a current Ph.D. student at City College of New York, addressed students in the SEE program about educational determination, willingness, and work ethic as prerequisites for academic success.

He described education as an extremely important part of one's life; it is not only the professor's job to teach you, but also your job to maintain a healthy academic ethic. This is why so many students move from school to school; they believe that professors in one school are superior to those at another. However, if one fails to put a significant amount of effort into one's education, then it doesn't even matter if Richard Feynman is one's professor because education begins with oneself, and it takes serious determination to make it in the field of Engineering. If one puts his or her entire mind and body into his or her work, then being an Engineer has limitless rewards. In a few years, you may be counted among the likes of Nikola Tesla and Alexander Graham Bell.

Seminar #2
Date: Friday, June 3, 2016, 12 pm – 2 pm
Presenter: Mr. Waseem Hussain, Student in Mechatronic Engineering
Topic: Union Crate Start-up Company

In the afternoon session of the SEE program, Mr. Waseem Hussain, an outstanding senior student in the Vaughn mechatronic engineering program and the Co-Founder & VP of Union Crate talked about his start-up company.

He explained how Union Crate is the first management platform food service operating system that bridges the gap between supply and demand by analyzing customer behavior and predicting demand for every product. He explained how his company reduces waste and increases revenue by moving excessive food.

Mr. Hussain shared his expertise by explaining how he balances his academic career with his start-up dream as well as how the right support services from both academia and business helped him successfully launch his idea.

Waseem Hussain Co-Founder & VP of Union Crate Start-up Company

<u>Seminar #3</u>
Date: Friday, June 17, 2016, 10 am – 2 pm
Presenter: Mr. Marvin Blackman, Control Systems Engineer at Wunderlich-Malec
Topic: Efficient Engineering

In the morning seminar session, Mr. Marvin Blackman a Vaughn alumnus and a control systems engineer at Wunderlich-Malec talked about efficient engineering and the processes required to be an efficient engineer in the workplace. He described engineering as an ever-evolving process, and engineers must realize there is more to engineering than what is documented in textbooks, taught by our professors and observed in the school setting. He emphasized the key building blocks in becoming an efficient engineer:

- Attitude vs Aptitude - Having the right attitude is the key to being successful in much more than just your professional career. Your attitude impacts more than the task at hand, it impacts the people around you, the project and the company you represent.
- Dedication - What does it really mean to be dedicated? It's more than just working long hours. Dedication means being committed to yourself, your coworker, your project and your company.
- Embrace Technology - Technology is all around us. But how do engineers embrace it when technology shows up at their company door.
- Be Resourceful - Remember that 90% of everything you see once you get out of school is going to be 'new'. You're going to hear terms like 'sink or swim', 'learning on the fly', 'on the job training' and much more that will imply we don't expect you to know it but we're sure you can figure it out. Being resourceful will work best if it is also coupled with dedication.

- Take Ownership - Engineering if it had to be a sport would be a team sport. Your aim is to be the individual who looks out the window for someone to praise and into the mirror for someone to blame. By using your window and mirror appropriately you are preparing yourself to be more than just an engineer, but a leader.
- Control Engineer - He also talked about his career and responsibility as control engineer. His presentation was followed by a 20 minute open discussion session with students.

The afternoon session included a workshop based on the Honeywell's Experion LX platform and Matrikon OPC Server. Experion is used in a distributed control system (DCS) for process control. Matrikon OPC server is used to take a number of propriety communication protocols and serves as the supervisory control and data acquisition (SCADA) system using the standard OPC protocol. The lab involved a hands-on demonstration of how points are configured in hardware and presented to the end-user by a human machine interface (HMI) in software. Students worked in groups of 3-4 and they were able to practice some of the key elements discussed in the morning presentation. This workshop included labs designed to simulate real world scenarios and to encourage teamwork.

Control System Workshop - The Honeywell's Experion LX platform and Matrikon OPC Server

Seminar #4

Date: Friday, June 24, 2016, 10 am – 1 pm, Room W143

Presenter: Mr. Derry Crymble, Academic Solutions Advisor at Quanser
Topic: Engineering product and feedback control system designs

Mr. Derry Crymble, Academic Solutions Advisor at Quanser, addressed students in the SEE program and talked about Quanser's engineering product and feedback control system designs in the workshop.

He began his discussion with a description of the three-year design procedure for the autonomous unmanned aerial vehicle - QBall system. The engineering design process involved need analysis, brainstorming for innovative ideas, computer simulation, repeated modification of the design, and implementation and testing.

After the introduction, Mr. Crymble took a rotary servo unit with the QFLEX 2 USB interfacing panel and MATLAB/Simulink software as an example to explain the working principle of a real-time feedback control system. He started from the open-loop system: control of the servo motor without a feedback signal from the encoder. The motor position was easily disturbed by external force. Once a feedback loop with P control was added, the motor position was stable due to an applied external force. However, the motor position response showed a large overshoot and steady-state error. With a PI control, the large overshoot disappeared. Finally in the presence of a PID control, both overshoot and steady-state errors were eliminated.

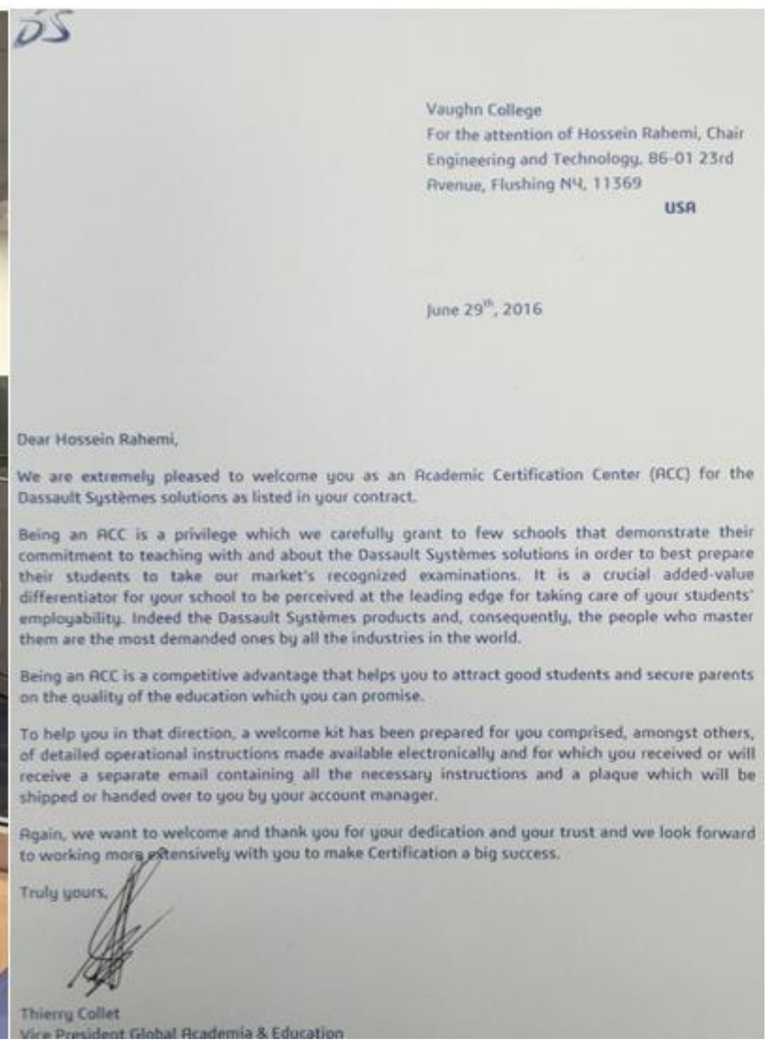
The workshop successfully provided students with first-hand experience on engineering project and control system designs.

CATIA Academic Certification Center

On Wednesday August 24, 2016, Vaughn College was selected to be the Academic Certification Center for the Dassault Systems solutions. As Academic Certification Center (ACC), Vaughn's students and students from other institutions and the industry will be able to take recognized CATIA Certification Exams at Vaughn College.

Peter Trogos, North American Academic Ambassador for Dassault Systems expressed his excitement about this new certification with his long-standing academic partner, Vaughn College. He expressed how Vaughn has always been in the forefront with offerings which impact the educational experience.

The certification program will bring Vaughn students industry recognition for their CATIA skills and proficiency. It adds credibility to Vaughn students and proves their capabilities in today's competitive job market. These capabilities are highly sought after by the industry, and our students are rewarded with highly-skilled job prospects.



Vaughn College
For the attention of Hossein Rahemi, Chair
Engineering and Technology, 86-01 23rd
Avenue, Flushing NY, 11369
USA

June 29th, 2016

Dear Hossein Rahemi,

We are extremely pleased to welcome you as an Academic Certification Center (ACC) for the Dassault Systèmes solutions as listed in your contract.

Being an ACC is a privilege which we carefully grant to few schools that demonstrate their commitment to teaching with and about the Dassault Systèmes solutions in order to best prepare their students to take our market's recognized examinations. It is a crucial added-value differentiator for your school to be perceived at the leading edge for taking care of your students' employability. Indeed the Dassault Systèmes products and, consequently, the people who master them are the most demanded ones by all the industries in the world.

Being an ACC is a competitive advantage that helps you to attract good students and secure parents on the quality of the education which you can promise.

To help you in that direction, a welcome kit has been prepared for you comprised, amongst others, of detailed operational instructions made available electronically and for which you received or will receive a separate email containing all the necessary instructions and a plaque which will be shipped or handed over to you by your account manager.

Again, we want to welcome and thank you for your dedication and your trust and we look forward to working more extensively with you to make Certification a big success.

Truly yours,

Thierry Collet
Vice President Global Academia & Education

LABORATORIES UPGRADE AND ENHANCEMENT

The engineering and technology department continues to improve the overall technological infrastructure in order to provide the best possible learning environment for students. For the past five years, the college has witnessed positive change directly related to the funding and support following the Title III grant "Broadening the Gateway to 21st Century Engineering Degrees for Underserved Hispanic Students", from the Department of Education. The engineering technology department was able to establish several state-of-the-art-laboratories such as the Thermo-Fluid lab, Robotics and Control System lab, automation lab, Energy Conversion and Smart Grid Power Systems lab, and the 3D innovation Center. These new facilities and upgraded existing facilities contribute to student success in both scholarly activities and technical competitions.

The new title III grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students", will further help the engineering department in the development of an advanced manufacturing program. Vaughn's faculty and staff are confident that through the effective and efficient use of grant funding, the college will successfully accomplish its vision for the future.

The department developed, upgraded and enhanced the following laboratories.

- **Energy Conversion and Smart Grid Power Systems Laboratory**

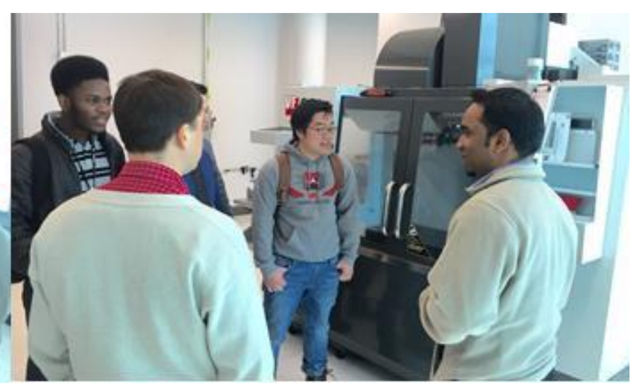
As part of US Department of Education (Title III HIS-STEM) grant, the engineering and technology department established a state-of-the-art **Energy Conversion and Smart Grid Power Systems Laboratory** in Fall 2015 ($350,000 power electronics equipment) with an objective to provide students in EE and Mechatronic Engineering programs with the hands-on experiences in smart grid and power electronics. This lab will complement lecture courses in Electromagnetism (ELE323), Electric Machines (ELE325), Power Electronics (ELE451), and Introduction to Power System (ELE452). This lab provide students with opportunities to observe and demonstrate fundamental theory pertaining to Electrical Machines, Power Electronics, Motor Drives Circuits & Controllers, contemporary techniques in Power Generation, Power Transmission, Power Distribution, and Energy Management of Load Consumption.

In fall 2015, the department established a 3 credit technical elective course (ELE454-Introduction to Electric Power Systems) for students in the mechatronic engineering program. This course was offered in spring 2016 and students expressed their appreciation for the hands-on knowledge they gained in the design and analysis of power systems.

➢ **NEW Machine Shop with A HASS VF-2SS CNC Milling Machine, October 2015**

Currently, the engineering and technology department is in the process of establishing a new CNC machine shop to facilitate the implementation process of a new manufacturing concentration within Vaughn's existing mechanical engineering technology program. In fall 2015, based on 2013 ABET team recommendations and 2014 & 2015 annual spring advisory meetings feedbacks, the engineering and technology department created a machine shop room and purchased a HASS VF-2SS CNC milling and cutting machine with all accessories. The new title III grant also provides necessary funding to support the completion of the new machine shop, faculty training, and a CNC manufacturing lab tech.

Both faculty and students should be able to use CNC machine shop for manufacturing parts for the laboratory testing samples, CAM and Prismatic Machining course assignments, and parts and components for their capstone degree projects. Also, this lab will be used to teach and conduct hands-on experiments for CNC programming, machining and the manufacturing process. In addition, students from both robotics and UAV clubs will be able to use this center to design and manufacture parts such as gear systems, body frames, and frame support components for their robotics and UAV projects.



- **Robotics and Control System Laboratory**

This lab is used to teach laboratory courses such as MCE101 (Introduction to Robotics), ELE326 (Microprocessor), ELE350 (Control System), MCE420 (Mechatronics II-Robotics) and has dedicated seating to instruct 15-20 students. This lab maintains equipment related to control system, Intelitek robotics, microprocessor, and mobile robots. In fall 2015, the department added 16 sets of robotics/software equipment from LEGO Education to further support and enhance students' hands-on experiences in the MCE101 ((Introduction to Robotics) course.

- **3D prototyping innovation center**

Currently the engineering and technology department is in the process of establishing its state-of-the-art 3D Prototyping Innovation Center to support current engineering programs as well as a new aeronautical manufacturing engineering technology program. The equipment listed below is supported by the HIS STEM Title III grant that ended in Dec 2016.

  - HASS VF-2SS CNC milling and cutting machine with all accessories, purchased in fall 2015
  - Eight 3D printers (two Formlabs, five MakerBot, and one Ultimaker) and one 3D Scanner, purchased during academic year 2015
  - One MARKFORGED composite 3D printer, three form 2 (Formlabs) 3D printers, and one Carbide Mini 3D CNC machine purchased during academic year 2016.

The support of new Title III grant will assist the department in the complete establishment of Vaughn's state-of-the-art 3D prototyping innovation center. This center will be used to teach hands-on computer-aided design and 3D printing manufacturing courses within all engineering and technology programs. Also, this center can be used by Capstone Degree Project students and UAV and Robotics clubs to design and build mechanical parts for their projects.

- **Mechanical Testing Laboratory**

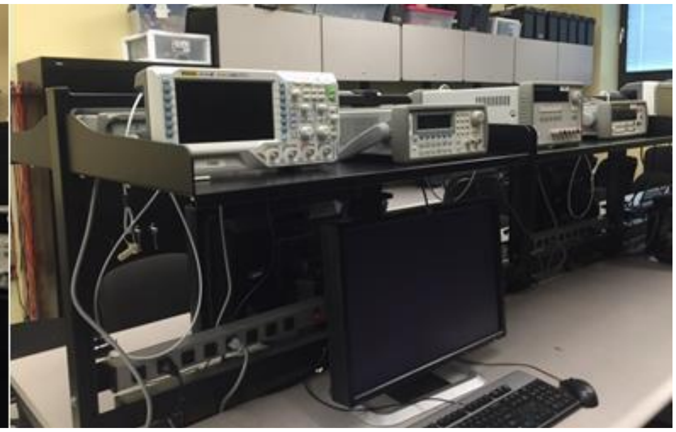
The mechanical testing lab is used to teach our core engineering courses. This lab has dedicated seating to instruct 15-20 students. The lab is equipped with Measurement Group, Inc. strain measurement hardware and measuring devices for instructional capability in stress analysis. Students can perform basic experiments in plane stress, torsion, and bending to verify the basic equations in strength of materials. The application of strain gauge techniques gives our students the fundamentals of laboratory procedures that apply to all technologies in engineering, in the aircraft industry, as well as in mechanical and civil engineering.

In fall 2015, the engineering and technology department purchased two desktop tensile machines and two furnaces for the Mechanical Testing Lab. This laboratory course complements lecture courses in solid mechanics concentration in our mechanical engineering program and provides our students with hands-on experiences in evaluating mechanical properties. This lab is equipped with a tensile machine, torsion machine, fatigue machine, impact machine, hardness machine, vibration testing equipment, strain measurement hardware and devices for stress analysis.

- **Electronics Laboratory**

The Electronics Lab is used to teach core analog and digital electronics courses. This lab has dedicated seating to instruct 20-25 students. The lab is equipped with several sets of digital oscilloscopes (2-channel, 100 MHZ), function generators (waveform generator, 20 MHZ), digital multi-meters (5.5 digit), power supplies (triple output), microprocessor and digital trainer equipment, and digital multi-meters. The Multisim circuit design and the LabView software are used to complement the lab portion of electronics courses. In fall 2012, the department added $31,000 of communication equipment with all its accessories (Basic unit, virtual instruments package, AC Fundamentals I & II, Analog Communication, and FACET Courseware and Manuals) from Tech-Ed Systems Inc to complement the lab component of principles of communication course.

In fall 2015, the engineering and technology department added four function generators, 10 power supplies, 10 digital oscilloscopes (100 MHz), and four spectrum analyzers (1.5 GHz) from TERA Technologies, Inc. With these additions, our current electronics lab will have adequate equipment to serve 20-25 students. This lab will be used to provide our students with hands-on experiences in electrical engineering and will expand their knowledge in the field of electronics.

- **Thermo-fluid Laboratory**

This lab has dedicated seating to instruct 15-20 students. In this lab students have the opportunity to conduct a wide range of experiments related to thermal and fluids sciences, such as measuring aerodynamic drag, liquids densities, hydrostatic pressure, Boyle-Marriott’s law, surface tension of liquids, flows in liquids & gases, heat exchangers efficiencies and free & forced heat convection coefficients. This laboratory course will complement lecture classes such as fluid mechanics, aerodynamics, and heat transfer.

In fall 2015, the engineering and technology department placed a purchase order for a High Speed Camera and CW laser; this equipment provides an important benefit to the thermo-fluid laboratory, and it will be used to complement the courses (MEE260-Aerodynamics, MEE360-Propulsion Power for Aircraft and Rocket Engines, EGR375-ThermoFluid) in our new mechanical engineering program.


COMPUTATIONAL PROJECT-BASED LEARNING

In an effort to improve and enhance students' critical thinking, problem solving, and teamwork learning outcomes, the engineering and technology department implemented a computational project-based learning model through computational methods in engineering and engineering analysis courses. In these courses, students will be introduced to numerical methods based on both finite difference and finite element approaches. Students are arranged in several teams, and each team is assigned to a technical project with a specific engineering application. The assigned project must be studied and investigated based on available mathematical principles and MATLAB computer programming. The students' projects will be measured based on learning objectives that are identified in the course syllabus and will be graded based on criteria such as proposal, model development, programming, analysis, report and presentation. Some of these students' computational-based projects were submitted and accepted for publication and presentation at technical conferences.

Industry Advisory Council

At Vaughn College, the industry advisory members have a pivotal role in program delivery and thus in students' subsequent success. The industry advisory members work closely with the faculty members of the engineering and technology department in developing new course offerings and program modifications. Their valuable recommendations and comments continuously make our program delivery stronger and more competitive with the growing demand of today's technology. Furthermore, the close partnership with these industrial companies, such as Sikorsky, Northrop Grumman Corporation, Defense Contract Management Agency, Corning, Lockheed Martin, SciMax Technologies, RCM-Tech, Rockwell Collins, Pavon Manufacturing Group, FAA, CPI-Aerospace, Wunderlich-Malec, US Didactic, Con-Edison, and MTA, allow our students to explore a career or an internship opportunity with top engineering enterprises.

Internship Programs

Vaughn's internship program is a key part of an engineering curriculum to prepare students for the workplace. For the past several years, our students were involved with both summer, and school year internship programs with top engineering companies such as Daimler, John Deere, NASA, Sikorsky, Northrop Grumman Corporation, Lockheed Martin, RCM-Tech, Rockwell Collins, Federal Aviation Administration (FAA), Alken Industries, Cummins Engine, MTA, GE, Pall Corp., Pavon Manufacturing Group, Raytheon, Safe Flight Instruments, Toyota, Robotics Education and Competition Foundation (RECF), and Naval Research Enterprise Internship Program (NREIP). These internships provided them with a greater appreciation for engineering education and expanded their hands-on and career-building experiences. As a result of those internships, many of our graduates are currently working with those companies as new advisory members for our programs, and assisting our current students in pursuing internships with those companies.

Faculty Professional Engagements and Workshop Participation

To improve the quality and effectiveness of instructional delivery and students' learning, the engineering and technology department encourages faculty members to participate in conferences and workshops designed to enhance faculty's understanding of new technological discoveries and innovations to maintain teaching quality. For the past few years our faculty members have been active participants in many educational and technical conferences and workshops such as the American Society for Engineering Education (ASEE), Latin American and Caribbean Consortium of Engineering Institutions (LACCEI), Aircrafts Electronics Association (AEA), Institute of Electrical and Electronics Engineers (IEEE), American Institute of Aeronautics and Astronautics (AIAA), Society for Experimental Mechanics (SEM), and American Society of Mechanical Engineers (ASME). Also, faculty were involved with the development and implementation process of two new mechanical and electrical engineering programs, laboratory development/enhancement, and developing learning communities for NSF scholarship recipients.

During the calendar year 2015–2016, faculty in the engineering and technology department participated in the following professional engagements and workshops:

Hossein Rahemi

1. In spring 2016, submitted an annual progress report for the title III STEM grant on implementation process for both new mechanical and electrical engineering programs. This report provides information and updates on new faculty, enrollment statistics, new laboratories development & enhancement.
2. Engineering and technology department hosted VEX U Robotics Regional Qualifier "Nothing but Net" challenge on Friday February 12, 2016.
3. Engineering and technology department hosted High School VEX Robotics Regional Qualifier "Nothing but Net" challenge on Saturday February 13, 2016.
4. Participated as VCAT robotics club adviser in 2016 CSM VEX U Robotics Challenge Regional Qualifier, February 5, 2016. Vaughn's Robotics Team finished 2nd in this Regional Qualifier Tournament Championship.
5. On Feb 11, 2016, the engineering and technology department chair presented the plan and process for the implementation of new mechanical and electrical engineering programs to the academic policy committee of the board of trustees. The department accepted students to ME program as of fall 2015 and will start accepting students to its EE program as of fall 2016. The department will provide an annual progress report to the NYSED on both ME and EE programs that includes information/updates on: new/refurbished facilities, faculty and staff, and preparations for ABET evaluation.
6. Participated as Vaughn's robotics team adviser in 2016 VEX U World Robotics College Championship. From April 20-23, 60 national and international universities and colleges; received invitation to participate in 2016 VEX U World Championship in Louisville, Kentucky, Freedom Expo Center. Invitation to the VEX U Robotics World championship is only granted to a team that is a tournament champion or excellence award recipient of a regional competition. Vaughn's Robotics team was 2015 tournament champion of the international congress of Technologies of Information and

Communication (Cancun, Mexico), tournament champion of the Manchester Community College (MCC) Regional Qualifier, finalists in College of Southern Maryland (CSM) Regional Qualifier, and recipient of Excellence Award of Vaughn College Regional Robotics Competition—which qualified the College to participate in 2016 VEX U World Championship. For the third year in a row, Vaughn's robotics team was able to advance to playoff round of VEX U World Championship. On Saturday, April 23, Vaughn College's Robotics team achieved the title of World Champions at VEX U beating 60 other college teams. In addition, the team also won Design Division Champion Award for demonstrating strong ingenuity and innovation in the design of their robots. They also received the Innovate Award.

7. Hosted the Eighth Annual Vaughn College's Technology Day Conference, April 28, 2016. The morning session was a meeting with our advisory members to share the contents of the NYSED approved mechanical and electrical engineering programs. The afternoon session was devoted to student capstone research project presentations and a poster session. The participants included industry advisory members from Sikorsky Aircraft Corporation, Corning Incorporated, SciMax Technologies, The Composite Prototyping Center, Pavon Manufacturing Group, NASA Education Department, Defense Contract Management Agency (DCMA), Honeywell, U.S. Didactic, Con-Edison, The Cotocon Group, BELCAN, U.S Patent & Trademark office, and City Tech CUNY.
8. Published the Eighth Annual Vaughn College Journal of Engineering and Technology (VCJET). This journal includes annual department activities, information on laboratory upgrades and development, faculty and student professional engagements, graduate success stories, industry tours, engineering seminar series, industry connection seminar series and student technical research papers (April 2016).
9. As a PI of the NSF S-STEM grant ($575,000 funded by NSF), monitored NSF learning communities' activities and engaged the 3rd and 4th years NSF scholarship recipients in professional engagements related to conference participation, conference poster competitions, and Robotics/UAV club activities & competitions.
10. Served as co-chair of the Middle States Steering Committee as well as co-chair for the committee on "Standard 11 – Educational Offerings" under the Middle States Accreditation Steering Committee for Vaughn College. A complete report regarding Vaughn's Educational Offerings with all supporting appendixes has been submitted to the Middle State Committee.
11. In spring 2016 developed and submitted a new Aeronautical Manufacturing program proposal for the title III HIS-STEM grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students" with all necessary supporting documentation and budget justification for equipment, faculty, and staff. The grant has been approved and funded for $5,999,754 by the department of education, 2016-2021.
12. On Thursday May 5, 2016, the engineering and technology department chair presented department activities to the Academic Policy Committee of the Board of Trustees; those were as follows:
    - Update on 2016 VEX U World championship and Vaughn's robotics team accomplishment as world champion of 2016.

- ➢ Update on Vaughn's Eight Annual Technology Day Conference that took place on April 28, 2016 and shared with the board members students' paper and poster sessions award recipients.
- ➢ Update on drone workshop hosted by UAV team to celebrate the international drone day on May 7, 2016.
- ➢ Update on Summer Engineering Experience (SEE) program that is designed to prepare freshmen students for the core courses within engineering programs. The SEE program is designed with an objective to enhance students' hands-on, computational, programming, communication, and problem solving skills.
- ➢ Update on students involvement in professional societies, conference participation, presentations, and publications.

13. Vaughn's UAV team paper "Color detecting and autonomously programming micro UAV" was accepted for the 2016 American Helicopter Society (AHS) Annual Micro Air Vehicle (MAV) Student Challenge. Their paper was selected as one of the finalist for the autonomous category of Annual Micro Air Vehicle competition. This competition took place on May 16, 2016 in West Palm Beach Convention Center.
14. Implemented a Summer Engineering Experience program (SEE) to prepare first-year students for engineering programs. The five-week SEE program was offered in the summer 2016. Monday through Thursday (from 8:00 am to 4:00 pm) sessions were devoted to the lectures and hands-on classes that covered topics related to engineering computation using MATLAB and C++, robotics, bridge truss design & analysis, technical writing and presentation. The Friday session of the SEE program is designated for technical seminars and workshops. This session is designed to enhance students' learning outcomes related to critical thinking, problem solving, and life-long learning.
15. On September 16, 2016, the engineering and technology department chair, Dr. Hossein Rahemi, along with the mechanical engineering program coordinator, Dr. Elzawawy, and Vaughn's UAV team met with the representatives of Cradle of Aviation Museum to discuss Vaughn's efforts to help them in hosting the middle school UAV competition at the Cradle of Aviation Museum.
16. An annual progress report for both ME and EE programs that includes information/updates on: new/refurbished facilities, faculty and staff, and preparations for ABET evaluation has been submitted to the NYSED on September 2016. Every September an annual report needs to be submitted to the NYSED until the department receives EAC- ABET accreditation for both of these programs.
17. On October 6, 2016, Dr. Rahemi presented department activities to the Academic Policy Committee of the Board of Trustees; those were as follows:
    - ➢ Enrollment statistics and implementation process of new mechanical and electrical engineering programs.
    - ➢ Update on drone workshop hosted by UAV team to celebrate the international drone day on May 7, 2016.
    - ➢ Update on UAV team project as one of the finalists for the American Helicopter Society Micro Air Vehicle (MAV) competition in West Palm Beach, Florida, May 16, 2016.

- ➢ Update on the development process of new Machine Shop and 3D Prototyping Innovation Center.
- ➢ Update on hosting the second Annual Manufacturing Day Conference on Friday October 28, 2016.
- ➢ Update on fall's Engineering Seminar and Industry Connection Seminar series.
- ➢ Update on students involvement in professional societies (ASEE, AIAA, ASME, LACEEI, IEEE, and SWE), conference participation, presentations and publications.
- ➢ Update on Robotics, UAV, and SWE, EWB clubs professional activities and competitions.
- ➢ Update on student placement (full-time position, internship, graduate programs).

18. On October 21, 2016, Department Chair, Dr. Hossein Rahemi, along with the mechanical engineering coordinator, Dr. Elzawawy, met with the principal of The Board of Cooperative Educational Services of Eastern Suffolk (ES BOCES STEM High School), Mr. Edward Moloney, to discuss and complete the program articulation agreement between the two institutions. This articulation agreement promotes an easy and efficient transfer of ES BOCES STEM High School graduates to Vaughn College engineering degree programs. Based on this agreement, ES BOCES's graduates who successfully complete the Pre-Engineering Program can transfer their computer aided design course toward two credits of CDE117- Engineering Graphics with SolidWorks at Vaughn College and also their robotics course can be used toward one credit of MCE101- Fundamental Robotics at Vaughn.
19. Hosted Vaughn's 2nd Annual Manufacturing Day Conference on October 28, 2016 to celebrate the National Manufacturing Month. Vaughn invited four presenters for the morning session to address invited guests and the college community about manufacturing innovation in the area of 3D printing, composite, robotics, and automation. In the afternoon session, IEEE Entrepreneurship hosted an on-site and livestream panel. The panelists for the entrepreneurship session were three Vaughn graduates who found their own start-up company.
20. The engineering and technology department chair met with EE curriculum committee on December 17 2015; the committee members discussed issues related to the current curriculum and made necessary modifications and preparations to accept students and offer this program in the academic year 2016-2017.
21. From November 7-9, participated as VCAT robotics club adviser in 2016 VEX U Reeduca Robotics "Starstruck" challenge in the Universidad Tecnológica de Querétaro, Queretaro City, Mexico. Vaughn's team finished first and won the tournament championship of this international competition.
22. Advised students on research papers and presentations for technical conferences:
    - Adviser for student papers, 2016 Vaughn College Annual Technology Day Conference, Vaughn College, NY, April 28, 2016.
    - Adviser for students' papers and posters, 2016 ASEE Annual Conference, June 26-29, 2016, New Orleans, Louisiana.

- Adviser for Vaughn College students' papers and posters, LACCEI 2016 Conference, July 19 to 22, 2016, San Jose, Costa Rica.

23. Organized several industry connection and engineering seminar series; the guest speakers and seminar topics are as follows:
    - Presenters: Mr. Fethi Guloglu, educational consultant, and Mr. Shahid Rahman, The Founder and President of I-SAY
      Topic: Service Learning - Teach & Travel program
      Date: Tuesday, February 9, 2016
    - Presenters: Mr. Matthew Pearce, NASA Education Programs Specialist
      Topic: NASA Goddard Institute for Space Studies Introduction
      Date: Tuesday, Feb 23, 2016
    - Presenters: Dr. Max Gross, President and Founder of SciMax Technologies
      Topic: The 21 Century Composite World, where is it heading?
      Date: Tuesday, March 22, 2016
    - Presenters: Dr. Tahani Amer, Manager for NASA's Program Assessment Office
      Topic: Computational Fluid Dynamics
      Date: Thursday, March 24, 2016
    - Presenters: Dr. Amir Elzawawy, Assistant Professor, and Saneela Rabbani, Mechatronic Engineering Class 2016
      Topic: The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convective Heat Transfer and Darcy Friction Factor
      Date: Thursday, Sep 29, 2016
    - Presenters: Mr. Ron Fazah, IT Solution Architect at JetBlue
      Topic: JetBlue's MRO Life Cycle Process and Implementation
      Date: Thursday, Oct 20, 2016
    - Presenters: Mr. Carlo Asaro, Avionics Engineer at Sikorsky
      Topic: Evolution of Aircraft Avionics Architecture
      Date: Tuesday, Nov 29, 2016
24. Participated as Vaughn's robotics team adviser in the fall 2016 Mexico's Robotics competition. The Vaughn College Robotics team, the world champion of 2016 VEX U Robotics world championship, was invited to participate in Mexico's VEX U Reeduca Robotics competition. From November 6-8, thirty four teams including Vaughn College Robotics team participated in Mexico's VEX U – Startrack Robotics competition. For the second year in the row, Vaughn's robotics team finished first and won tournament championship of this competition.
25. From December 6-8, participated in Middle States Commission on Higher Education (MSCHE) annual conference. The following are a list of pre-conference Workshops and conference sessions in which I participated
    - Reinvesting the student experience: Providing service to meet the changing needs of students
    - Successfully organizing a meaningful decennial review
    - Aligning Accreditation and planning
    - Building and benefiting from the documentation roadmap

- Developing lifelong leaner: Assessing student learning in a tutoring program.
- Embedding assessment in everyday practice

26. As a Principal Investigator (PI) of Title III STEM grant, conducted several meetings with faculty, academic vice president, industry advisory members, and the academic policy committee of the board of trustees to review, discuss, and update them about the status of two new mechanical and electrical engineering programs, students' professional engagement and accomplishments as well as new laboratory developments. Some of these activities for the academic year 2015–2016 can be categorized as follows:
    - Presented department activities, faculty and student professional engagements, and process for the new ME and EE programs implementation to the Academic Policy Committee of the Board of Trustees on Feb 11, May 5, and Oct 6, 2016.
    - Met with program coordinators and faculty to update new electrical engineering curriculum sheet, course offerings, transfer policy and its implementation for fall 2016.
    - The Engineering and Technology department completed the establishment of its state-of-the-art **Energy Conversion and Smart Grid Power Systems Laboratory** in fall 2015. This laboratory provides our electrical engineering students with hands-on experiences in smart grid and power electronics fields. This lab will complement lecture courses in Electromagnetism (ELE323), Electric Machines (ELE325), Power Electronics (ELE451), and Introduction to Power System (ELE452). Also, the department established a three credit technical elective course (ELE454-Introduction to Electric Power Systems) in mechatronic engineering program. This course was offered in spring 2016 and students expressed their satisfaction with the hands-on knowledge they gained concerning the design and analysis of power systems, as well as the type of faults these systems can experience.
    - In September 2016, the engineering and technology department established its state-of-the-art 3D Prototyping Innovation Center to support current engineering programs as well as the establishment of a new aeronautical manufacturing engineering technology program. This center is equipped with multiple high quality 3-D printers that are listed below and is supported by the Title III grant
        - ➢ Eight 3D printers (two Formlabs, five MakerBot, and one Ultimaker) and one 3D Scanner, purchased during academic year 2015
        - ➢ One MARKFORGED composite 3D printer, three form 2 (Formlabs) 3D printers, and one Carbide Mini 3D CNC machine purchased during academic year 2016.
27. In January 2017, submitted a closeout report for the title III STEM grant "Broadening the Gateway to 21st Century Engineering Degrees for Underserved Hispanic Students". This report provides information and updates on the implementation process of two new mechanical and electrical engineering programs, new faculty, enrollment statistics, new laboratories development & enhancement, program articulations, and student engagement in scholarly & professional activities.
28. As a Project Director of the new Title III STEM grant, "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students", will conduct meetings with faculty, advisory members,

academic vice president, and president regarding development process of manufacturing certificates and BS aeronautical manufacturing program. Currently department placed two faculty position opening announcements for a manufacturing program developer, and a composite program developer & designer. Also, a manufacturing Lab-tech position opening has been announced during fall 2016. A search committee will be organized in spring 2017 to review candidates' credentials, conduct phone interview and select the most qualified person for the campus interview.

Amir Elzawawy

1. Attended as a judge in LIESF (Long Island Engineering and Science Fair) annual event at Woodbury, NY, February 2, 2016.
2. Attended an AVID faculty training session on Content-Specific WICOR (writing, inquiry, collaboration, organization, reading) organized and hosted by Vaughn College, March 4, 2016.
3. Awarded and Participated with two students from Vaughn's Mechatronic Program in the Department of Energy Visiting Faculty Program at Oak Ridge National Laboratory, from June 6 to August 12, 2016. 10-week research program was related to Coolant Fluid Simulation over newly designed 2nd Generation Target Holder.
4. Served as a member of Middle States Steering Committee in addition to co-chairing subcommittee of Standard 8 "Student Admissions and Retention" as part of Middle States Accreditation process.
5. Administrated and monitored students in NSF-STEM Scholarships program. The program encompasses more than two cohorts of 15 students for the period of four academic years of each cohort.
6. As program coordinator of new Mechanical Engineering Program, submitted annual academic professional development activities and the goals for the upcoming year.
7. Advised and mentored more than three teams of students to develop research journal papers for VCJET 2016. The projects were presented in the afternoon session of 8th Annual Vaughn College Technology Day Conference on April 28, 2016.
8. Conducted and Collected advisory members evaluation surveys for student technical paper and poster sessions of 8th Annual Vaughn College Technology Day Conference, April 28, 2016.
9. Assisted Vaughn's UAV club in hosting one day drone workshop on May 7 2016 to celebrate the drone international day.
10. Participated with Vaughn's UAV team as one of the finalist for the American Helicopter Society Micro Air Vehicle (MAV) competition in West Palm Beach, Florida, May 16, 2016.
11. Participated as a student advisor at the ASEE's 123rd Annual Conference and Exposition in New Orleans, Louisiana that ran from June 26 through June 29. Vaughn's students' project titled "**Design and Implementation of a Braille clock"** by Saneela Rabbani and Josiah D'Arrigo received the 2nd place award of 2016 ASEE Manufacturing Student Division Competition.
12. On Monday August 8th, along with Vaughn's students presented our research findings regarding the 2nd generation target hold design.to DoE's Reactors Research Division at Oak Ridge National Lab.

13. Participated in department meeting on September 8, 2016 to discuss student advisement, Supplemental Instructors list for each program, course schedule, plans for Industry Connection Seminar series, Engineering Seminar series, collecting graduate Exit Surveys, Internship Supervisor Surveys, Employer Surveys, and Alumni Surveys and conducting annual course and program assessment reports.
14. On September 16, 2016, the engineering and technology department chair, Dr. Hossein Rahemi, along with the Mechanical Engineering program coordinator, Dr. Elzawawy, and Vaughn's UAV team met with the representatives of Cradle of Aviation Museum to discuss Vaughn's efforts to help them in hosting the middle school UAV competition at the Cradle of Aviation Museum.
15. Presented a talk along with Ms. Saneela Rabbani about our summer research program, titled "The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convective Heat Transfer and Darcy Friction Factor", during fall engineering seminar series, Sept. 29, 2016.
16. Participated in Vaughn's 2nd Annual Manufacturing Day conference on October 28, 2016 and assisted UAV team in hosting drone workshop "Learn to build a drone" and drone flying practice session for high school students.
17. Attended at COMSOL Multiphysics Conference and presented my summer research program with department of energy titled "The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convective Heat Transfer and Darcy Friction Factor" and "Computational Fluid Dynamics Analysis of Turbulent Flow in a 2nd-Generation Irradiation Target Holder at HFIR". Boston MA, Oct 5-7, 2016
18. Attended along with students a field trip to Brookhaven National Lab, Upton NY. Students visited several facilities and learned about the internship opportunities by DoE, Oct 14, 2016.
19. On Nov, met with NSF-S STEM students to discuss plans and clarify the program requirements and activities for the academic year 2016/2017.
20. As an advisor of AIAA student chapter/Unmanned Arial Vehicles club, met with students to discuss their readiness for 2018 American Helicopter Society Micro Air Vehicle (MAV) competition.

Shouling He

1. Served as a member in Mission and Vision Committee for Middle States Accreditation, 2014-present.
2. As a program coordinator of mechatronic engineering program, submitted annual academic professional development activities and the goals for the upcoming year. Also responsible for course and program assessment.
3. Advised students through their research papers and presentations for the technical conferences:
    - Advisor for SWE students' paper titled "Create Interests in Engineering with Girl Scouts" at 2016 ASEE St. Lawrence Conference, April 9, Cornel University, NY. The paper has been published in Journal of Transaction on Techniques for STEM Education, July-Sept, 2016. Recipient of the best paper award.
    - Advisor for students' papers and posters at the 2016 Vaughn College Annual Technology Day Conference, Vaughn College, NY, April 28, 2016.

- Advisor for students' posters titled "A Braille Clock" and "Automated Pill Dispense" at the 2016 ASEE Annual Conference, June 26-29, 2016, New Orleans, Louisiana. Vaughn students' project titled "**Design and Implementation of a Braille clock"** by Saneela Rabbani and Josiah D'Arrigo received the 2nd place award of 2016 ASEE Manufacturing Student Division Competition.
- Advisor for Vaughn College students' poster at LACCEI 2016 Conference, July 19 to 22, 2016, San Jose, Costa Rica. Students' poster titled "Innovative Robotic Designs for VEX U Challenge - Nothing But Net" by Alex Uquillas and Kent Oqisu received the 2nd place award.
- Advisor for Vaughn's SWE club at the 2016 Society of Women Engineers (SWE) Annual Conference, October 27-29, 2016, Philadophia, PA. Vaughn's SWE students hold a workshop at this annual conference.

4. Mentor for three NSF-STEM Scholarship recipients in their research works with two posters at 2016 Vaughn Technology Day Conference and published in VCJET.
5. Completed the online course "Aerial Robotics", held by University of Pennsylvania, with 100% correct rate in all quizzes and programming assignments, and got the Certificate, June 3-July 10, 2016.
6. Attended Mechatronics Education Technology Workshop held by NYU and Quanser Consulting, Inc, June 17, 2016 and introduced the Mechatronics Engineering Education at Vaughn College.
7. Attended the workshop "The negotiation skill" held by C&F women's initiative, CEO Advantage Spring, June 22, 2016.
8. Attended the industry connection seminar, "Engineering System Design and Feedback Control System", by Mr. Derry Crymble, Quanser Consulting Inc, June 24, 2016.
9. Worked as a faculty Instructor for Summer 2016 Vaughn's Pre-Engineering Program. Taught 11-12th grade high school students the basic concepts of Engineering Design and Robotics as well as robotic programming and helped high school students design and implement robot projects, July-August, 2016.
10. Worked as a faculty instructor for Zion/Vaughn Pilot Program. Developed and taught a course in Introduction to Robotics to middle school students, Summer 2016.
11. Worked as a faculty instructor for 2016 Summer Engineering Experience (SEE), taught students robot system designs and programming.
12. Attended as a judge for (1) Freeport High School Science and Engineering Fair, April 29, 2016; (2) Vaughn College VEX Robotics High School Qualifier, February 13, 2016; (3) College University VEX Qualifier, February 12, 2016.
13. Attended along with students a field trip to Curtiss-Wright Corporation, as part of Manufacturing Day event, Oct.4, 2016.
14. Participated in EE curriculum committee meetings to discuss and update the classes and laboratories and evaluated students' qualifications to apply the program.
15. Participated in Vaughn's 2nd Annual Manufacturing Day conference on October 28, 2016.
16. Participated in the AVID for Higher Education Initial Program
17. Participated in the First International Drone Event at Vaughn College, May 7, 2016.
18. Represented engineering and technology department in Faculty Senate Committee: discussed, examined and passed the new version of Faculty Handbook as well as completed the pre-tenure evaluations for two faculty members.

19. Participated in both fall and spring open house events and provided a presentation of Mechatronic program, automation laboratory, and SWE club activities to the open house participants.

Yougashwar Budhoo

1. Developed and presented an Introduction to CATIA course (35hrs.) for Performance Plastics LTD. at the Composite Prototyping Center, Plainville N.Y from July to August, 2016.
2. Advised and mentored students through their capstone degree projects and assisted them with their research papers for the technical conferences (VCJET, ASME and LACCEI).
3. Mentored two groups of NSF-STEM Scholarship recipients in their research work.
4. Developed and presented a short course on the design and analysis of composite materials for high school students at the Composite Prototyping Center, Plainville N.Y on April 5th, 2016
5. Adviser for students' poster presentation entitled "Universal Allen Key" at the LACCEI 2016 Conference, in San Jose, Costa Rica, July 21st, 2016
6. Adviser for students' poster presentation entitled "Bio-Composite use for a Milling Machine Table" at the LACCEI 2016 Conference, in San Jose, Costa Rica, July 21st, 2016
7. Presented a short course on the analysis of composite materials for high school students at the Composite Prototyping Center, Plainville N.Y on November 19th , 2016
8. Develop teaching material and laboratory experiments (damping) for EGR 230 course (Mechanical Testing and Evaluation Lab).
9. Developed teaching material for CDE 490 (CATIA Composite Product Design) which was taught during fall of 2016.
10. I was an active member in the workgroup #8-Educational Offerings, during Vaughn's preparation for Middle States assessment.
11. Completed course level assessment for courses in the Mechanical Engineering Technology (MET) Program
12. Distributed, collected, and analyzed surveys (exit, alumni, internship, and employer) from our students, alumni and employers for 2016.
13. Started working on the program level assessment for the MET program.

Flavio Cabrera

1. Developed new contents for an introductory course on power systems for ELE454. This activity started in January and continued throughout the Spring 2016 semester.
2. Continue development of contents for the introductory course on mobile robots (MCE420). This activity started in January and continued throughout the Spring and Fall 2016 semesters.
3. On Jan 20, 2016, participated on SHPE Adviser Track conference call.
4. On Feb 12, 2016, Served as judge at the VEX U Regional Robotics Competition, hosted at Vaughn College.
5. During Spring 2016, work with Mr. Maniell Workman (student from the Mechatronics program) on the analysis of (FDI) system for multi-robot systems.
6. Participated in several industry connection and engineering seminar series as listed below

- Presenters: Mr. Fethi Guloglu, educational consultant, and Mr. Shahid Rahman, The Founder and President of I-SAY
  Topic: Service Learning - Teach & Travel program
  Date: Tuesday, February 9, 2016
- Presenters: Mr. Matthew Pearce, NASA Education Programs Specialist Topic: NASA Goddard Institute for Space Studies Introduction
  Date: Tuesday, Feb 23, 2016
- Presenters: Dr. Max Gross, President and Founder of SciMax Technologies Topic: The 21 Century Composite World, where is it heading?
  Date: Tuesday, March 22, 2016
- Presenters: Dr. Tahani Amer, Manager for NASA's Program Assessment Office Topic: Computational Fluid Dynamics
  Date: Thursday, March 24, 2016

7. On March 23, 2016, attended the Queens Chamber of Commerce – Energy Committee meeting on cogeneration, solar energy, legislation, energy assessment, and equipment-based ECM's.
8. On March 2016, provided a review to a paper submitted for publication to the 2016 IEEE International Conference in Robotics and Automation (ICRA).
9. On April 7, 2016, attended seminar on "Gravitational Waves" by Vladimir Tarnovski.
10. On April, 2016, provided a review to a paper submitted for publication to the 2016 IEEE International Conference on Intelligent Robots and Systems (IROS).
11. On Sept 2, 2016, attended seminar on "MEC401-Mechatronics Internship - The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convective Heat Transfer and Darcy Friction Factor" by Saneela Rabbani.
12. Starting in June 2016, collaborative work on Engineering Education with Dr. Clara Nieto-Wire, Assistant Professor in the Mathematics Department at CUNY– Hosts Community College. Research topic: "Developing Concrete Intellectual Tools (CITs) for STEM Courses and Artificial Intelligence Systems".
13. Throughout 2016, collaborative work on Robotics systems with Dr. Xiaohai Li, Assistant Professor in the Computer Engineering Technology Department at CUNY–City College of Technology. Research topic: "Analysis of Exploration Algorithms for Multi-Robot Systems".
14. Work, along Dr. Xiaohai Li, in the preparation of the manuscript titled: "Study of the fleet size problem in multi-robot systems" to be submitted for publication.
15. Work, along with Dr. Xiaohai Li, in the preparation of the manuscript titled: "Robust Output Feedback Tracking Control of Active Magnetic Bearings".

Rex Wong

1. Participated in EE curriculum committee meeting for the newly NYSED approved Electrical Engineering program and made necessary modification for implementing this program in fall 2016.
2. Submitted a journal paper which has been accepted and published in 2016 ASEE Journal of Manufacturing Division. The title is "MAKER: An Entry-level Robotic System Design

Project for K-12 and Undergraduates". This is the follow-up for NSF funded summer research program, RET (Research for Teachers) held at Texas A & M University from June 8 until July 18, 2015. This program is particularly focused on research experiences for teachers in Mechatronics, Robotics, and Industrial Automation.

3. Attended ASEE 123rd Annual Conference & Exposition in New Orleans, Louisiana, for presenting a poster in Makers Poster Session, June 28, 2016.
4. Represented Vaughn College at the energy committee meeting of Queens Chamber of Commerce at Astoria, NY, May 19, 2016. This event might help Vaughn to establish industrial relationship for students studying power/energy courses.
5. Participated on drone workshop hosted by UAV team to celebrate the international drone day on May 7, 2016.
6. Attended the event of Vaughn Women Engineer Club to support SWE club's activities on April 28, 2016.
7. Attended Engineering without Border event at Vaughn to support EWB club agendas and activities, April 15, 2016.
8. Attended the 2-days RoboUniverse Conference held at Javits Center, NYC, April 10-11, 2016. This conference integrated robotics, drone, and 3D printing into one topic.
9. Attended Industry Connection Seminar by Dr. Tahani Amer, NASA Supervisor of Engineering Project Management on Thursday, March 24, 2016. The topic is: "Computational Fluid Dynamics to Project Management and Opportunities for Students at NASA".
10. Participated in VEX Sky-Rise competition as judge at Freeport High school in Long Island, NY in Feb. 6, 2016.
11. Participated in VEX Sky-Rise competition as judge at Vaughn campus in Feb. 13, 2016.
12. Presented my NSF funded summer research program titled "A Learning Module Dedicated to Enhance the Study of Robotics and Mechatronics "conducted at Texas A&M University at the fall Engineering Seminar Series on Oct. 1, 2015.

<u>Manuel Jesus</u>

1. Participated Star Citizen Spacecraft Design for Games Workshop. CGThrive, Los Angeles, California (November, 2015)
2. Printed 3D models for the Robotics club and other Vaughn College students using the Fortus 250mc 3d Printer and Form 2 printers. (Ongoing)
3. Participated in the Hass CNC Basic Training Workshop (October, 2016).
4. Attended Markerbot 3d Printing in Education Seminar at NJIT. Newark NJ (October, 2016)
5. Received Artec Eva and Spider 3D scanner training from Allegheny Systems (November, 2015).
6. Attended 3DS Max and Maya User Group meetings with students at the Auto Desk NYC Office (November 2015).
7. Developed presentation materials related to 3D printing and manufacturing (December 2015).
8. Researched and sourced cost effective and reliable technology for 3D Innovation Lab (January, 2015).
9. Attended New York City 2014 International Toy Fair N.Y., N.Y (February, 2016)

10. Participated in Mark Forged composite 3d printer training (March, 2016).
11. Developed and taught 3D design and printing course for high school students in the Upward Bound program (July, 2016).
12. Developed and taught SolidWorks 3D printing course for elementary school students (August, 2016).
13. Worked with Dr. Rahemi and Mr. Peter Trogos to establish Vaugh College as Catia certification testing center (August, 2016).
14. Deployed 3D Printing and Innovation Lab, tested equipment and installed required software related to 3D printing, desktop CNC, and 3D scanning (August, 2016)
15. Volunteered on Motorola 68000 series CPU platform studies preservation project using FPGA technology and small scale manufacturing techniques. Developed graphics for branding, tech demos, and operating system ROM upgrades. Apollo Team, Thunder Bay, Ontario, Canada (July, 2016).
16. Served on Middle States Committee related to Student Retention.
17. Ongoing professional development in toy manufacturing consisting of package design, product design, and 3d model development.

Khalid Mouaouya

1. Worked as a faculty instructor for 2016 Summer Engineering Experience (SEE), taught students engineering mechanics.
2. Participated In ASEE2016 Annual Conference and Exhibition, June 26-29, 2016, New Orleans, Louisiana.
3. Participated with Vaughn's student and faculty in LACCEI 2016 conference at San Jose, Costa Rica, July 19 to 22, 2016.
4. Participated with Vaughn's Robotics team in the fall Mexico's VEX U Reeduca Robotics competition, November 7-9, 2016.
5. Participated in all Vaughn's spring and fall 2016 Industry Connection Seminar Series, and Engineering Seminar Series.
6. Participated in 2nd annual Vaughn's Manufacturing Day conference on Oct. 28, 2016.
7. Advisor of Engineers Without Borders (EBR) club, fall 2015-present.

Mudassar Minhas

1. Serving as co-chair for committee on "Planning Resources Allocation and Institutional Renewal" under Middle States Accreditation Steering Committee for Vaughn College.
2. Currently serving on committee for revising Vaughn College Faculty Handbook.
3. Improvement modifications to lab equipment and lab exercises for Radar Systems, Laboratory Standard Practices, Integrated Avionics Systems, and Pulse Systems. Additionally, conducted repair in-house on radar system saving the department approximately $5000.00
4. Developed Arduino C programming and sensor integration exercises for Microprocessors course.
5. Seminars:
    - "An Introduction to RF Design" – Part II of Wireless Communications Series by Rohde & Schwarz, Feb 4, 2016
    - "Protecting the Next Generation of High Speed Buses" by Arrow Electronics, Feb 10, 2016

- “Sensors and How to Use Them by Analog Devices and Arrow Electronics”, Mar 9, 2016
- “Cost Effective Magnetic Sensors and CAN with Flexible Data Rate” by Infineon Technologies AG, May 5, 2016
- “Multidimensional Sensing - Accuracy in Miniature: 3D Magnetic and Pressure Sensors” by Infineon Technologies AG, May 18, 2016
- “Integrating the Right Security in Smart Homes” by Infineon Technologies AG, Jun 7, 2016
- “Power Management Solutions for Modern Appliances” by Infineon Technologies AG, Jun 16, 2016
- “Securing the Networks and Servers in the IoT's Nervous System” by Infineon Technologies AG, Jun 21, 2016
- “RF Discretes: For Flexible and Reliable Complementary Wireless Connectivity” by Infineon Technologies AG, JUL 5, 2016
- “Foundation IP for Automotive ICs: What Do You Need?” by Synopsys, Jul 19, 2016
- “Emerging Vision Technologies: Enabling a New Era of Intelligent Devices” by QUALCOMM, Jul 20, 2016

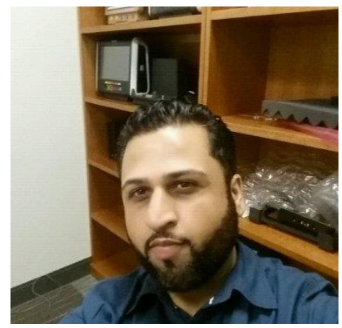
Jacob Glanzman

1. Serving as math and physics coordinator for Arts and Science department, also coordinating activities between Engineering departments and Arts and Sciences for courses and professors.
2. Member of Standard 12 committee for the Middle States Accreditation Association evaluation of Vaughn College programs.
3. Served as a judge for the college Robotics competition at Vaughn College on January 27, 2017.
4. Developed new course contents along with lab exercises for the engineering physics courses PHY125 and PHY225.
5. Attended as Speaker at Vaughn Freshman Orientation on August 12, 2016.
6. Attended AVID Professional Development Workshop, November 18, 2016.
7. Seminars and Presentations attended:
    - Vaughn Speaker Series with Airbus CEO Barry Eccleston 10/23/2017.
    - Aviation Safety with Honorable Chris Hart 10/24/2016.
    - Industry Connection Seminar 10/29/2016, 2/23/2016.
    - Vaughn Engineering Seminar 9/29/2016.
    - Vaughn Technology Day 4/28/2016.

GRADUATE SUCCESS STORIES

Given the rapid pace of technological change, the Engineering and Technology Department at Vaughn College adopted a set of in-class and out-of-class academic activities designed to prepare students for the growing demands of today's technology and to aid them in their future careers. These activities are designed with the intention of instilling awareness of continual technological change and the importance of lifelong learning in order that these students meet their future professional challenges.

Whatever path our engineering and engineering technology students choose, their Vaughn education thus provides them with an edge for success.



1. **Fahad I. Qureshi, Class of 2009**
   Project Lead Engineer
   DePuy Synthes (Johnson & Johnson)
   Associate's Degree in Aeronautical Engineering, 2007
   Bachelor's Degree in Mechanical Engineering, 2009

I was always interested in finding out how machines are constructed and how the components operate seamlessly together in order for a machine to perform its function. When I was younger, my older brother (who is also an engineer) and I would take apart our Matchbox cars and put them back together. Sometimes, we would swap out the wheels from each other's cars and then show-off our modified versions to our friends.

During high school, I preferred mathematics and science courses over those in business and arts. Towards the end of my junior year at high school in New Jersey, one of my close friends and I looked at colleges and universities offering engineering degrees with a concentration towards aviation. The College of Aeronautics (as Vaughn College was previously known) attracted my attention due to its small size and location directly across from an international airport in New York City. I registered for an open-house which I attended with my older sister. We were pleased to meet with the staff and faculty of the college who answered all our questions in detail, and we felt the positive energy of this institution. Upon my return, I filled out the application and sent it along with my transcript, SAT scores and the application fee. Sometime during the 1st half of my senior year at high school I received my acceptance letter, and I was very excited to move to New York and to begin my coursework at the college.

During my time at Vaughn College, I really enjoyed the mathematics, engineering, CAD and business related courses, which provided me with a solid foundation to launch my engineering career.

After earning my Associate's Degree in Aeronautical Engineering, I interned at Sikorsky Aircraft (Lockheed Martin) and I worked in the assembly area of Black Hawk military helicopters. I also worked with their engineering design team, which used the CATIA software. After earning my Bachelor's Degree in Mechanical Engineering, I started working for a Swiss-

American medical device design company called Synthes, now known as DePuy Synthes (Johnson & Johnson) as a Manufacturing Engineer, Project Engineer and Lead Project Engineer. I began this work originally in their factory in upstate New York, and I now work in their corporate office and factory near Boston, MA.

My advice to prospective and current students of Vaughn College is to work and study hard, ask a lot of questions of the college faculty and support staff and continue to practice discipline in the pursuit of your dreams.

2. Dominick (Nick) Visciotti
Team leader Aerospace Assembly Engineering
Cyient Inc. North America
A.O.S – Vaughn College of Aeronautics

As a young child aircraft and aerospace were secret and exciting elements in my childhood imagination. Coming from a working-class construction and mechanics background family it was hard for me to imagine anything else for my life. Therefore, as I grew older, I learned the family business and went into construction.

In the late 80's the construction and building industry experienced challenges and work became limited. Now with a family of my own I came to a crossroad in my life. Not having many other skills besides the ability to renovate homes and fix cars, I wondered what would be the next chapter of my career. After considerable thought, I decided I would go to college and become an aircraft maintenance technician. Much to the surprise of my family I enrolled in Vaughn College of Aeronautics for the start of my new journey.

After graduating from Vaughn, I began working in the airline industry. I worked with Tower Air Inc., Access Air, American Trans Air, US Airways and ultimately American Airlines. However, another turn of events would yet again change my career path.

After the cataclysmic event of 9/11/2001 American Airlines needed to re-evaluate their position in the airline industry, and I was laid off in June 2003. With nowhere to go in the airline industry at this time I returned to my construction roots but I would not give up on my aerospace career. During this time a customer told me she worked for Pratt & Whitney Aircraft Engines. She was surprised to discover that I had my Airframe and Power Plant licenses and that I had 10 years of industry experience. Through the connection this customer provided, I was able to re-enter the aerospace industry by working as a mechanic for Pratt Whitney. After two years at Pratt I decided I wanted to work as an engineer. I then connected with my current company Cyient Inc. who brought me on as assembly engineer to create various designs for the engine assembly floor. I received recognition for my designs as new work came into the company, and I was thus promoted to my current position as Assembly Engineering Team Leader.

Today I am the owner of two businesses, and I credit my overall success to my decision to attend Vaughn College of Aeronautics.

2. Shahidul Islam, Class of 2011
B.S. in Mechatronics Engineering – Vaughn College of Aeronautics
M.S. in Mechanical Engineering – City university of New York
Mechanical Engineer, Urban Engineers of New York, D.P.C

"*Develop a passion for learning. If you do, you will never cease to grow*" - D' Angelo.
I have always believed that by sticking to one's dreams with passion and strong commitment, a person can achieve almost anything in life. In 2007, I began my journey by attending Vaughn College. As a pioneer freshman in Mechatronics Engineering, I felt overwhelmed; however, within the first few weeks I realized that this college would guide me in the pursuit of my dream. With guidance chiefly from Dept. Chair Dr. Hossein Rahemi as well as from other professors, I regained my confidence. Mechatronics introduced me to all major engineering programs and the automation labs gave me hands-on industry experience. With the expertise I acquired in designing, programming, and core electro-mechanical principles I was given the opportunity to join NASA in my senior year.

Working in GSFC (Goddard Space and Flight Center) in Maryland as a Mechanical Engineer was the realization of a dream. My work in GSFC involved designing parts for ISS (International Space Station) to assist astronauts in space. I was also involved in Grover mission (autonomous vehicle) measuring ice layers in Greenland to provide data for global warming.

Immediately after my graduation, I began work with Pavon Mfg. designing and testing US Army Defense Contracts. Afterwards, I joined Vaughn as a Lab Tech. while completing my MS in City University. I am currently working with Urban Engineers as a Mechanical engineer on a 10 million dollar project in United States Merchant Marine Academy. Working in the construction industry offers many wonderful challenges and opportunities. My current responsibilities as a CM include, but are not limited to - project management, contract administration, overseeing budget and schedules, and maximizing efficiency and productivity of the project.

Vaughn made me well equipped for this industry. In my undergraduate work I was involved in various research paper publications in LACCEI and ASEE international conferences. The financial support that Vaughn provided allowed me to attend those international conferences which provided me with the network that ultimately shaped my career. I am currently pursuing a PE license and planning to have my own design firm in near future.

Ultimately, it was Vaughn College that provided me with the leadership and management skills that have been so instrumental in the achievement of my career goal.

Industry Tour

1. Field trip to Maker Faire, Queens, NY

On October 1 and 2, 2016, Dr. Rex Wong and several Vaughn engineering students traveled to the New York Hall of Science in Queens, New York to attend Maker Faire, a popular event promoting invention, creativity and engineering within an old fashioned country fair. Eventually, this event evolved into a showcase for entrepreneurship and start-up businesses connected to hand-craftsmanship. Basically a gathering of tech enthusiasts, educators, hobbyists, engineers, authors, artists, students, and commercial exhibitors, these "makers" gather at the fair to show what they have made and to share what they have learned. In addition to more than 950 Maker entries, the fair featured six stages and six attraction areas with more than 150 presentations and shows. This year, the founder of Maker Faire, **Dale Dougherty**, provided us with an inspirational presentation about the inception of the Maker's movement and his future vision of the event.

Our group visited a large number of stands, including those of popular robotic vendors such as LEGO, VEX, Kuaka, and NAO. The vendors demonstrated many applications built from robotic kits, such as mobile robots, robotic arms and hands, exoskeleton devices like prosthesis, as well as PLC automation assembly lines.

The most spectacular event was the aerial show of drones where big companies like DJI, Parrot and 3D-robotics, as well as smaller companies, displayed and promoted their products.

In addition to robotics, there were 3D-printing machines where vendors exhibited their products. Many legacy technologists were also there to revive interest in space exploration and HAM amateur radio clubs. Internet of the Thing was another significant topic that pervaded the event.

This assembly of inspirational shows provided STEM motivation to students, as well as reviving the DIY spirit in the cyber-space era.

2. Field Trip to Brookhaven National Laboratory October 14, 2016

On October 14, 2016, Dr. Hossein Rahemi, Chair of Engineering and Technology at Vaughn College of Aeronautics and Engineering, Dr. Amir Elzawawy, Program Coordinator for mechanical engineering, Mr. Ernie Shepelsky, Vice President of Enrollment, and seven students from Vaughn College's Engineering and Technology Department visited the Brookhaven National Laboratory (BNL) in Upton, New York. The tour was organized by Danilo Archbold, Co-Founder of Zion Youth of Elmont and included visits to three facilities at the lab.

The group's first tour was to The Relativistic Heavy Ion Collider (RHIC), the second largest heavy ION collider in the world. This trip was followed by a visit to the National Synchrotron Light Source II, a newly built one-billion dollar facility that produces the brightest x-rays in the world. These x-rays are used to support basic science research, applied research in biology and medicine, materials and chemical sciences, and nanoscience.

The third tour was to the Center for Functional Nanomaterials (CFN), one of five Nanoscale Science Research Centers funded by the Department of Energy's Office of Science. This center provides state-of-the-art tools for creating and exploring the properties of materials with dimensions spanning just billionths of a meter. CFN scientists are dedicated to atomic-level tailoring that addresses a wide range of energy challenges such as improving solar cells and other electronic nanomaterials, designing more efficient catalysts, developing new capabilities and uses for electron microscopy, and nanofabrication based on soft and biological nanomaterials. All of these processes are supported with theory and advanced computation.

The Vaughn faculty, students and staff expressed their appreciation to Mr. Ken White, the manager of Educational Programs; Mr. Noel Blackburn, manager of University Relations and DOE WDTS Internship Programs; and Mr. Sal Gonzalez, Technical Support of Educational Programs for providing exciting and informative tours and for encouraging Vaughn's faculty and students to participate in BNL summer research programs.

Field Trip to Brookhaven National Laboratory, October 14, 2016

3. Manufacturing Day Field Trip to Curtiss-Wright Corporation

On Friday, October 14, 2016, thirteen Engineering and Engineering Technology students, along with faculty member Dr. Shouling He, attended an industry tour to Curtiss-Wright Corporation. This tour was arranged by Ms. Caron, Associate Director of Vaughn College Career Services, and Daniel Khodos, a sophomore student in the Vaughn Mechatronics Engineering program. These students and staff members visited Curtiss-Wright manufacturing facility which produces different types of CNC milling machines and the valves used in the defense industry as well as in the home building industry. During the presentation and discussion period, team engineers explained in detail how to design and manufacture a mechanical valve and a solenoid valve, as well as how to test them in the final production period. This tour reinforced in students an appreciation for their engineering education as they were brought to understand how their classroom instruction translates into the design process of an industrial product.

Manufacturing Day Industry Tour to Curtiss-Wright Corporation

Engineering Seminar
Thursday, September 29th 2016
11 am – 12 pm
Room E101 & E103

Topic: The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convective Heat Transfer and Darcy Friction Factor

Presenter: Dr. Amir Elzawawy, Assistant Professor in Engineering Technology department, and Saneela Rabbani, Mechatronic Engineering Class 2016

In this seminar Dr. Amir Elzawawy and Miss Rabbani who participated in a ten-week department of energy (DOE) summer research program at Oak Ridge National Laboratory, addressed both faculty and students about their research project entitled "The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convective Heat Transfer and Darcy Friction Factor".

Their ten week summer research program at Oak Ridge National Laboratory was supported by the office of Workforce Development for Teachers and Scientists (WDTS) at the Department of Energy in order to assist the Research Reactors Division (RRD) in designing a 2nd Generation irradiation target holder.

Their presentation was followed with a twenty-minute open discussion session.

Industry Connection Seminar
Thursday, October 20, 2016
11 am – 12 pm
Room E101 & E103

Topic: jetBlue's Maintenance, Repair, Operation (MRO) Life Cycle Process and Implementation

Presenter: Mr. Ron Fazah, IT Solution Architect at JetBlue

In this seminar Mr. Fazah, an IT solution architect at jetBlue, discussed his professional experiences as well as some of his current projects at jetBlue. Mr. Fazah presented a "real-world" example of the architectural process with some of the artifacts he used or created during the architecture and implementation of jetBlue's current Maintenance, Repair, and Operation (MRO) system.

Mr. Fazah shared his educational and professional background with faculty and students. He noted that it is important to listen to what clients or coworkers think they need and then counsel them on their actual needs. According to Mr. Fazah, "The right design is not always what is wanted, but what is needed." Ultimately, in order to attain career success, he noted "If you understand the fundamentals of anything, that knowledge can be applied across vast domains."

Mr. Fazah is an alumnus Vaughn College of Aeronautics and Technology, and he has more than 20 years of technical and leadership experiences with the Engineering and Computer industries. He graduated from Vaughn College with an AAS degree in Electronics Technology and started his first position as an Electronic Engineering Technician with Loral Electronics Systems, now a part of Lockheed Martin Defense Systems. While working at Lockheed, Mr. Fazah completed his BS in Electrical Engineering Technology and MS in Computer Science at NYU. At Loral/Lockheed Martin Defense Systems, he worked on top secret software and hardware designs for F15 and F16 fighter aircrafts. Mr. Fazah's presentation was followed with a 15 minute open discussion session.

Industry Connection Seminar
Tuesday, November 29, 2016
11 am – 12 pm
Room E101

Topic: Evolution of Aircraft Avionics Architecture

Presenter: Mr. Carlo Asaro, Avionics Engineer at Sikorsky

In this seminar Mr. Asaro, an avionics engineer at Sikorsky, talked about some of his professional experiences as an aircraft avionics system designer at Sikorsky Corporation, based in Stratford, Connecticut. Mr. Asaro has more than 30 years of experience in design, development, testing, and evaluation of rotor-wing electronics with primary focus on power electronics and weapon systems.

Mr. Asaro's presentation focused on current factors that are changing the way avionics designers are moving away from the design-from-scratch approach towards more advanced development processes and what this change means for students who pursue careers in the aerospace industry. He explained how size, weight, power consumption and cost savings in avionics architecture are realized by using more advanced development processes involving hydraulics, fly-by-wire and digital databases rather than analog signals. His presentation also focused on growing customer needs, and he discussed some challenges in the use of new and unproven commercially available technology with an existing helicopter.

"It is very important that before you go into the aerospace industry, you take courses in avionics," said Asaro. "Equipping yourself with that knowledge will definitely help you on your path". His presentation was followed with a 15 minute open discussion session.

Industry Connection Seminar
Tuesday, Feb 13, 2017
3 am – 4 pm
Vaughn's Lobby

Topic: ArcBest Corporations: Mission and History

Presenter: Mr. Jefferson Maldonado, a R&D Robotics Engineer at ArcBest

In this seminar Mr. Maldonado, R&D Robotics Engineer at ArcBest, talked about his professional experiences as well as the use of robotics in the logistic industry. He focused on the automation and robotics which are changing today's engineering industry including his logistic company. He discussed the advancement and efficiency of robotics in facilitating the design, production, and manufacturing process. He also talked about the summer robotics and mechanical internship programs with ArcBest and he urged Vaughn engineering students to take advantage of these career-building opportunities with his company.

His presentation was followed with a 15 minute open discussion session.

Industry Connection Seminar
Thursday, Feb 23, 2017
11 am – 12 pm
Room W155A

Topic: The Current and Future State of Commercial Jet Engine Technology

Presenter: Mr. William H. Brown, a Commercial Engines Marketing Manager at GE Aviation

In this seminar Mr. Brown, Commercial Engines Marketing Manager at GE Aviation, talked about some of his professional experiences as well as the current and future state of commercial jet engine technology, engine hardware display, technology development and more. He provided insights concerning his company, and he explained current research into the development of less expensive and more reliable aircraft engines.

He discussed how carbon fiber and ceramic materials used in today's Ge jet engines provide high efficiency, and how additive manufacturing with 3D printing technology is used for the construction of turbine blades. These processes also enhance the reliability of today's GE's jet engine production.

His presentation was followed with a 15 minute open discussion session.

Industry Connection Seminar
Tuesday, Feb 28, 2017
11 am – 12 pm
Room E101 & E103

Topic: Entrepreneurship

Presenter: Mr. Mr. Ken Stauffer, CEO and Co-Founder of Technology Assurance Labs and Co-Chair of the IEEE Entrepreneurship committee

Mr. Stauffer is an alumnus of our former institution, the Academy of Aeronautics, and he currently serves on Vaughn's Board of Trustees. After finishing at the Academy, he went on to receive a master's degree in Electrical Engineering from Polytechnic University in New York City, and he began his career at AT&T Bell Laboratories, which for many years was a major international technology think tank.. Currently he is CEO and Co-Founder of Technology Assurance Labs as well as Co-Chair of the IEEE Entrepreneurship committee.

In this seminar Mr. Stauffer talked about his professional experiences as well as topics related to startups, entrepreneurship, current technology, and engineering education. He talked about the traits of entrepreneurs and the large company versus the entrepreneurial start-up. He also elaborated on how to move from an idea to a product, intellectual properties protection, the US patent process, product development and marketing, and financing options.

His presentation followed with a 20 minute open discussion session.

Vaughn’s Manufacturing Day, Oct 28th 2016, 10 am to 2 pm

Engineering and Technology department hosted its 2nd Annual Manufacturing Day conference on October 28th to celebrate national manufacturing month. Vaughn College invited four presenters for the morning session to address invited guests and the Vaughn community about manufacturing innovation in the area of 3D printing, composites, robotics, and automation.

Mr. Jamie Moore, the Chairman and President of the Aerospace and Defense Diversification Alliance in Peacetime Transition (ADDAPT), talked about Additive Manufacturing/3D printing, robotics, composites and their impact on the industrial base. He emphasized how these programs with hands-on facilities can prepare graduates for today’s growing manufacturing industry.

The second presenter, Mr. Manny Santana, Vaughn alumni and a Quality Assurance Specialist at Defense Contract Management Agency (DCMA), talked about the philosophy of “Detection and Prevention” in the manufacturing process. He described how the current manufacturing initiative is to move from detecting problems with supplies to preventing problems from occurring. This philosophy is known as “Detection to Prevention” or D2P. In order for us to move in that direction, we must understand “why” we must and “how” we can meet this goal.

The third presenter, Mr. Oliver Scheel, President of US Didactic, talked about the Manufacturing Fundamentals and System Applications at Vaughn College. He described industrial automation and its impact on the manufacturing process.

The fourth presenter, Prof. Manuel Jesus, a Vaughn faculty member in the engineering and technology department who has vast knowledge in computer aided design, computer aided manufacturing, and 3D printing, talked about the advancement of 3D printing and its impact on the manufacturing process. He described the development process of Vaughn’s 3D Prototyping Innovation Center using multiple high quality and fast 3D Printers and scanners. He emphasized that establishment of both the 3D Innovation Center and Haas Computer Numerical Control (CNC) machine shop will not only provide our engineering and engineering technology students with hands-on manufacturing skills but also facilitate the development of the new aeronautical manufacturing program that is supported by the Department of Education federal fund as part of Title III, Part F, HSI-STEM and Articulation grant (Award#P031C160021).

Presenters addressed invited guests and Vaughn community about manufacturing innovation in the area of 3D printing, composites, robotics, and automation

In the afternoon session, as part of the Vaughn College Annual Manufacturing Day Conference (10:00am – 2:00pm), IEEE Entrepreneurship hosted an on-site and livestream panel. The panelists for the entrepreneurship session were three Vaughn graduates from the engineering and technology department who founded their own start-up company. The panelists for this session were Mr. John Pavon (Founder & President of Pavon Manufacturing Group), Mr. Cannon Patel (Founder Cannon Technology Group LLC), Mr. Waseem Hussain (Co-Founder & VP of Union Crate), and the session moderator was Ms. Randi Sumner, Senior director of IEEE strategy and entrepreneurship. The panelists provided insights on how to balance an academic career with their start-up and how the right support services from both academia and business helped them successfully launch their idea.

IEEE Entrepreneurship livestream panel

From 11 am to 2:00 pm, Vaughn's UAV and Robotics clubs organized and hosted workshops on building a drone, robotics design, and autonomous program. In the afternoon, the UAV club organized a drone practice flying session in the hangar. The participants for the workshops and drone flying session were students from Freeport, Bayside, and Thomas Edison high schools.

UAV and Robotics Workshops with a practice flying session in the college hangar

Vaughn's International Drone Day, May 7, 2016 10 am to 3 pm

On Saturday May 7, 2016, the engineering and technology department hosted several drone workshops such as Arduino Programming, CAD Modeling of Quadcopters, and Learn to Build a Drone in order to celebrate the International Drone day. The event allowed visitors and students to design, build, and test their own drones in the netted flying arena of the college hangar.

These workshops, organized by the engineering and technology department and the Unmanned Aerial Vehicle (UAV) club, coordinated the event in an effort to raise awareness of these flying devices. Arduino workshop introduced participants to the programming, automaton, and flight controllers of drones. The CAD workshop provided participants with insight into 3D design and the modeling of Quadcopters. Finally, the Learn to Build Drone workshop introduced participants to the building and manufacturing process of flying robots.

In the afternoon, participants were able to fly their drones in the Vaughn hangar flying arena. Vaughn's UAV team flew their drone that had been selected by the American Helicopter Society (AHS) as a finalist in the autonomous category for the 2016 AHS Micro Air Vehicle (MAV) competition. This competition will take place on May 16, 2016 in West Palm Beach Convention Center. Besides Vaughn's team four other schools (Georgia Tech, North Carolina A&T State University, North Dakota State University, and University of Maryland) were also considered finalists in the Autonomous Category. Vaughn's UAV team provided a brief presentation of their drone design, which employed 3D printing parts and autonomous programming, to the participants of Vaughn's International Drone Day.

Vaughn's International Drone Day – May 7, 2016

Vaughn's UAV team participated in the American Helicopter Society Micro Air Vehicle (MAV) competition, May 16, 2016

Vaughn's UAV team paper "Color Detecting and Autonomously Programming Micro UAV" was accepted for the 2016 American Helicopter Society (AHS) Annual Micro Air Vehicle (MAV) Student Challenge. Their project was selected as a finalist in the autonomous category of Annual Micro Air Vehicle competition. This competition took place on May 16, 2016 in West Palm Beach Convention Center.

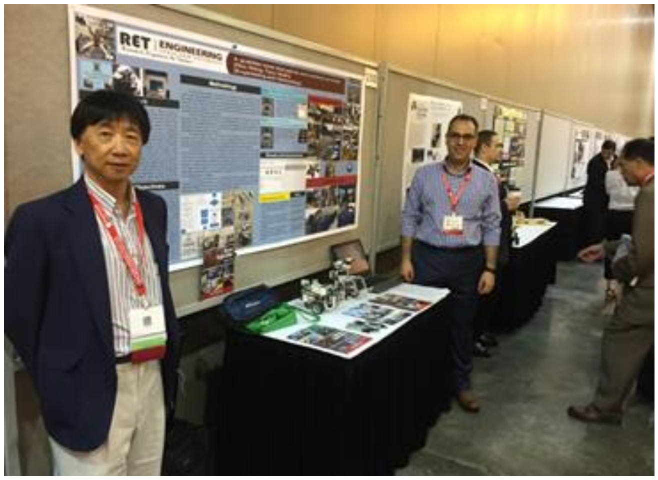
In the autonomous category, six members of the Vaughn College UAV team (Wassem Hussain, Nicholas Kumia, Bobby Tang, Utsav Shah, Andrew Aquino, Daniel Khodos) participated and competed against four other finalists from Georgia Tech, North Dakota State University, North Carolina A&T State University, and University of Maryland in the American Helicopter Society (AHS) International's Annual Micro Air Vehicle (MAV) competition. The purpose of this competition was to execute "search and monitor" obstacle avoidance and to return to a base station using only an onboard set of cameras. There were three targets as well as wall-like obstacles between the base and the target search area. As each stage is successfully completed, and each target is successfully identified, teams are awarded points. However, no team was successful at completing all required tasks in this autonomous competition.

Vaughn's engineering students and faculty presented their research projects at 2016 ASEE Annual Conference and Exposition.

Four Vaughn College students along with faculty from the engineering and technology department presented their capstone research papers at the ASEE's 123rd Annual Conference and Exposition in New Orleans, Louisiana that ran from June 26 through June 29.

On Tuesday, June 28, the Vaughn students' capstone design projects "**Design and Implementation of a Braille clock**" by Saneela Rabbani and Josiah D'Arrigo and "**A Low Cost Automated Pill Dispenser for Home Use**" by Christopher Chariah, Nicholas Kumia, and Jonathan Zubarriain were presented during a maker event Conference Session. Saneela's and Josiah's project presented ideas about designing and building a more efficient braille-time telling device that assists blind people in accurately recognizing time. Nicholas' and Chris' project presented ideas about the development and manufacture of an automated pill dispenser to serve elderly patients by reducing both chance of overdose and unnecessary healthcare expenses.

Dr. Rex Wong's summer NSF research project entitled "**A Guardian Robot that Patrols and Monitors our Home**" was presented during the Tuesday Maker Event Session of the ASEE annual conference. His presentation focuses particularly on research experiences for teachers in Mechatronics, Robotics, and Industrial Automation. For this summer project, Dr. Wong has developed a robotic course module unit to teach entry level robotics by using LEGO Mindstorms NXT kits to build a prototype domestic service robot called Max2, whose function is to check our home lighting condition if we are away from home. It can be either autonomous or remotely controlled by humans via a wireless communication link (Bluetooth or WiFi).



Vaughn students' projects were selected as finalists for the afternoon ASEE Design and Manufacturing division competition. The student project entitled "**Design and Implementation of a Braille clock"** by Saneela Rabbani and Josiah D'Arrigo received the 2nd place award in the 2016 ASEE Manufacturing Student Division Competition.

Vaughn's Engineering Faculty and Students Participated in LACCEI2016 Conference; Vaughn's Students Take Second Place at LACCEI 2016 Poster Competition

From July 19-22, Vaughn's engineering and technology students along with department faculty attended the LACCEI 2016 Conference in San Jose, Costa Rica. Three Vaughn student team research papers were accepted for presentation and publication in the LACCEI2016 international conference; one out of three submitted papers was accepted for the student paper session competition and all three were also accepted for the poster session competition of LACCEI2016.

From 11 am to 1 pm on Thursday July 21, one of our student team papers was presented to the international conference audience during the student paper competition session of LACCEI2016. The "**Use of Bio-Composites for a Milling Machine Table**" by Johnathan Shakhmoroff and Damian Gaona was a finalist for the student paper session competition.

LACCEI2016 Student Paper Session Competition

LACCEI2016 Poster Competition

From 2 pm to 4 pm on July 21, a total of 45 posters were presented during the poster session of the LACCEI Poster Competition, including three of Vaughn's student team posters. Our student research poster, "**Innovative Robotic Designs for VEX U Challenge-Nothing But Net**" by Alex Uquillas and Kent Oqisu won the second place award and silver medal in the student poster competition. Besides the above mentioned research project, two additional Vaughn student research projects were presented during the poster session competition: "**Engineering a Universal Hex Key to Optimize Work Efficiency"** by Bobby Tang & Nicholas Kumia and

“Use of Bio-Composites for a Milling Machine Table” by Johnathan Shakhmoroff and Damian Gaona.

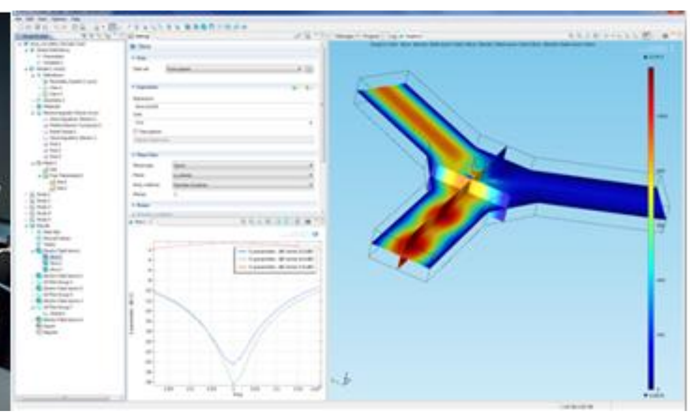
Kent Oqisu, Vaughn's Mechatronic Engineering Graduate, received the second place award in the student poster competition from Director of LACCEI, Dr. Maria Petrie.

COMSOL® Multiphysics Workshop

On October the 12th, Prof. Minhas attended a day-long workshop on COMSOL® Multiphysics simulation software held at Boston University in Boston, MA. COMSOL® software offers numerous modeling and simulation modules in the categories of electrical, structural and acoustic, fluid and heat, and chemical.

This workshop focused on practical hands-on training on the “RF Module” in Electrical category, particularly the low and high frequency electromagnetics. Frequency electromagnetics are directly related to the design of aircraft communication, navigation and radar systems. This software quickly demonstrates the operation of many components of the aircraft RF systems by modeling and simulating electromagnetic wave propagation and resonant behavior. A very interesting example used in this workshop consisted of a 3-port E-plane circulator of a typical X-band weather radar system.

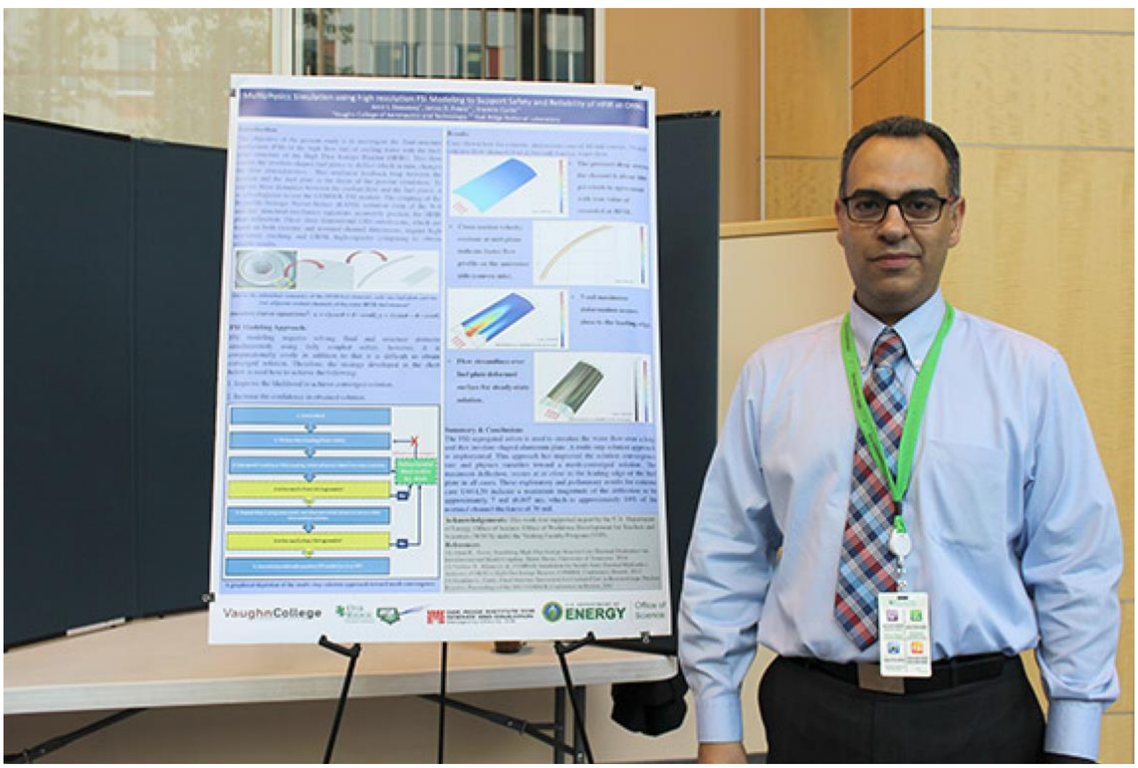
In summary, this software enables designers and engineers to compute electromagnetic field distributions, transmission, reflection, impedance, and power dissipation. In addition, simulation offers the ability to evaluate and predict physical effects on system components that are not directly measurable in experiments and that greatly enhance student learning.



Vaughn Faculty Member Receives Spotlight Award for Research conducted at the Oak Ridge National Laboratory (ORNL)

Engineering and Technology Assistant Professor Dr. Amir Elzawawy received the Spotlight Award for conducting engineering research after spending the summer of 2015 at the Oak Ridge National Laboratory (ORNL). Dr. Elzawawy was accepted as an ORNL educational program participant and he conducted nuclear research in hopes of understanding the mechanical interaction of high-speed coolant flow nuclear research reactor fuel plates. This specific research was important because it highlights safety risks that may occur when one is in contact with high or low risk uranium reactors.

Dr. Elzawawy learned how to use software for researching nuclear reactors. He also learned how to use software modeling and simulation in his thermal science courses, and he learned how to stimulate student learning through these subjects. He succeeded in bringing the knowledge he attained through his work inside the High Flux Isotope Reactor (HFIR) into his curriculum. His students now use Multiphysics in their capstone degree projects.



Vaughn's Faculty and students participated in the Department of Energy (DoE) summer visiting faculty research Program at Oak Ridge National Laboratory (ORNL)

Dr. Amir Elzawawy assistant professor in the Vaughn engineering technology department and Saneela Rabbani and Josiah D'Arrigo, Mechatronic Engineering Class 2016, participated in visiting faculty program supported by office of Workforce Development for Teachers and Scientists (WDTS) at the Department of Energy. The ten-week-summer research program was at Oak Ridge National Laboratory to support Research Reactors Division (RRD) in designing 2nd Generation irradiation target holder. This program is particularly focused on advancing research supporting the US Department of Energy and ORNL mission.

Under the supervision of Dr. Elzawawy Saneela conducted research entitled "The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convective Heat Transfer and Darcy Friction Factor", and Josiah conducted research entitled "Computational Fluid Dynamics Analysis of Turbulent Flow in a 2nd Generation Irradiation Target Holder at the High Flux Isotope Reactor using COMSOL Multiphysics".

Brief descriptions of their research are as follow:

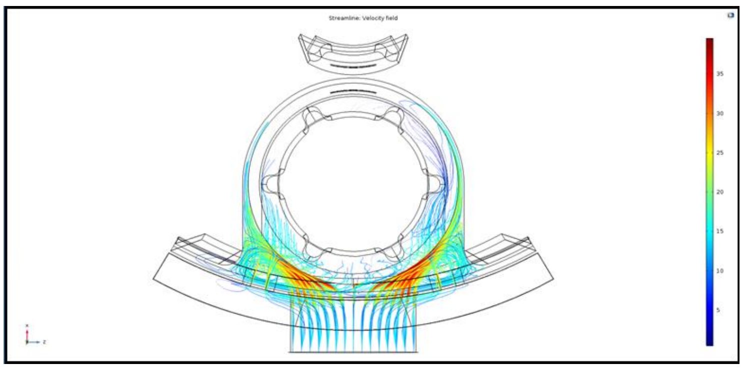
1. **The Effect of Eccentricity in Fully Developed Annular Pipe Flow on the Convection Heat Transfer and Darcy Friction Factor**

   Eccentricity in annular channels contributes to changes in fluid flow characteristics which in turn affects the performance and integrity of the configuration. This research investigates a model of an annular channel with a diameter ratio of 0.762, an aspect ratio of 68.9:1 and heating of the internal surface of the inner cylinder with a 1.105MW/m^2 heat flux. The Reynolds number ranges from 5,000 to 85,000 and non-dimensional eccentricity (e*) ranges from 0 to 0.92. The results have shown gradual, but significant changes as the eccentricity is increased. The resulting velocity and temperature profiles significantly affected the Darcy friction factor, convective heat transfer coefficient, and Nusselt number. This study was conducted, in part, to support an ongoing project to implement a design change for a 2nd-generation irradiation target holder at the High Flux Isotope Reactor (HFIR) of Oak Ridge National Laboratory (ORNL).

Velocity magnitude (lower left) Temperature for fully developed annular flow for different eccentricities

2. **Computational Fluid Dynamics Analysis of Turbulent Flow in a 2nd-Generation Irradiation Target Holder at the High Flux Isotope Reactor using COMSOL Multiphysics**

The primary purpose of the Oak Ridge National Laboratory's (ORNL) High Flux Isotope Reactor (HFIR) is nuclear isotope production. Recently, HFIR staff was tasked to investigate the possibility of producing isotopes needed to power deep-space flight vehicles for the National Aeronautics and Space Administration. To improve the production process, we are designing a new irradiation target holder, known as the second-generation irradiation target holder (2-GITH). Heat is generated during the irradiation process; thus, we performed a computational fluid dynamics (CFD) analysis to determine if the design for 2-GITH provides sufficient coolant flow (5 gpm to each of seven simultaneously-irradiated targets). To simulate the flow through 2-GITH, we used COMSOL Multiphysics, with its conjugate heat transfer k-ε turbulent flow module. Since 2-GITH has six-fold rotational symmetry with one central target and six outer targets, we can simply analyze a "pie-slice"-shaped sector representing one sixth of the model.



Streamlines with colors indicating the velocity magnitude inside the 2^{nd} generation irradiation target holder

Vaughn College Research Team at ORNL

SWE Vaughn Chapter Holds A Workshop at 2016 SWE Annual Conference

The Society of Women Engineers (SWE) 2016 Annual Conference, the world's largest conference and career job fair for women in engineering, was held October 27-29, in Philadelphia, PA. The SWE Vaughn Chapter has successfully organized a number of workshops over a broad range of topics for middle/high school girls as well as college students. After rigorous selection, the SWE conference committee approved the worshop entitled "Cross-culture Immersion Simulation: an Opportunity to Develop Intercultural Collaborative Skills Firsthand". The core organizors of the workshop are Vaughn College students, Emily German (Vice President of SWE Vaughn Chapter), Samntha Maddaloni (President of Engineers w/o Boarder) and Lovedeep Kaur (Head of Fundraising of SWE Vaughn Chapter) with Dimitri Papazoglo (President of SWE Vaughn Chapter) providing the opening presentation. All SWE Vaughn Chapter students, led by Dr. Shouling He, assisted at the meeting.

Figure 1: All SWE Vaughn Chapter Members Organizing and Attending the Workshop

During the workshop, attendees were separated into western and eastern cultures, and immersed in a cross-cultural simulation to experience firsthand the challenges and advantages of multicultural collaboration. After assimilating to a new culture, a person was challenged to accomplish the task of developing a mini building while working mono-culturally and then while working inter-culturally. The purpose was to examine how respect and integration of new cultures requires thoughtful strategies and effort. The workshop was so interesting that many attendees from different universities, such as University of North Texas and George Mason University, felt that they had learned a lot about how to work effectively with people from different cultural backgrounds.

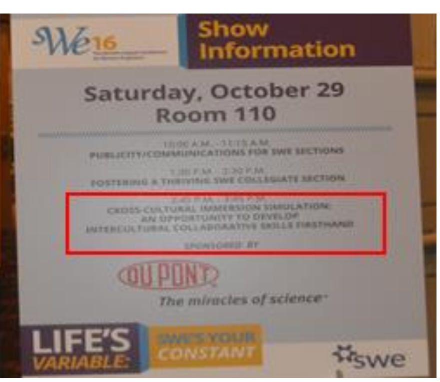


Figure 2: The Workshop Held by SWE Vaughn Chapter at 2016 SWE Annual Conference

Before the workshop, sixteen students joined the career fair. Prior to coming to the conference, SWE Vaughn Chapter organized several meetings and seminars to help students write resumes and handle interviews. Experienced students, such as the previous president of SWE Vaughn Chapter Monica Vanterpool, who received three interviews and two internships from Toyota and John Deere last year, enthusiastically shared her knowledge about conducting a good interview. After full preparation, Vaughn students received interviews from Johnson Controls, Boeing, Daimler, Northrup Grumman, Raytheon, John Deere, P&G, Exelon, Rockwell Collins, Toyota, Harley Davidson, Honeywell, Cummins, Alcoa, Con Edison, Kohler, and Lockheed Martin.

Among them, Emily German (junior in mechatronics engineering) received a Summer 2017 internship from Daimler; Betsy Sanchez (senior in mechatronics engineering) received a Spring 2017 cooperation internship from Toyota and a job offer from Cummins; Lovedeep Kaur (junior in mechatronics engineering) received a Summer 2017 internship from John Deere; Jessica Jemenz (junior in mechanical engineering technology) received a Summer 2017 internship from Raytheon; Darwing E. Mota (senior in mechanical engineering technology) received a final interview from Exelon; and Damian Gaona (graduate, mechanical engineering technology) is in the process of obtaining employment from Lockheed Martin.

The workshop at the conference assisted students in the realization that they can help others by sharing their engineering experiences. They learned that as long as they hold a positive attitude and continually improve themselves, they will be able to reach their career goals.

Freeport High School Science and Engineering Fair

The Freeport High School Annual Research Fair took place on Friday, April 29, 2016. More than 100 students' research projects in engineering, mathematics, physics, and science were presented during 2016 Annual Science and Engineering Fair.

Three faculty members, Hossein Rahemi, Shouling He, and Khalid Mouaouya from Vaughn College were invited by Freeport High School as judges to evaluate student engineering research projects. Each faculty member was assigned a maximum of six projects.

Students Presentation at Freeport High School 2016 Annual Research Fair

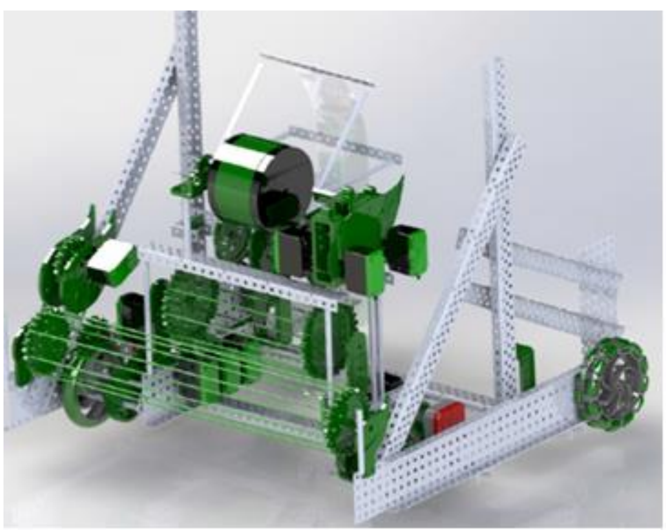
2016 VEX U Robotics World Championship Competition
Vaughn's Robotics Team is 2016 VEX U Robotics World Champion

Innovative Robotic Designs for the 2016 VEX U "Nothing But Net" Challenge

Every year, VEX Robotics challenges the problem-solving skills of science, technology, engineering and math (STEM) scholars. Competition participants used robotics platforms and engineering processes to solve this year's challenge entitled 'Nothing But Net." For this purpose Vaughn's team designed, built, and programmed two robots to compete in matches consisting of a forty-five second autonomous period followed by one minute and fifteen seconds of driver-controlled manipulation. The team constructed their robots to attain the following objectives:

1. Launch balls consistently, rapidly, and accurately from any location on the field to basket.
2. Move quickly for best defensive and offensive performance
3. Control Algorithms for best autonomous performance
4. Have an effective and rapid elevation mechanism that also complies with the limitations and constrains of the challenge.

Both robots feature the same launcher. The launcher itself was strategically designed in terms of wheel weight and maximum rpm to have a favorable release rate and small recovery time. With control algorithms, the wheel launches balls at varying locations away from the goal and releases them with pinpoint accuracy. Additionally, both robots feature the same drive-train transmission in order to shift from a low speed/ high torque mode to a high speed/low torque mode in order to demonstrate the greatest speed and strength of any robot on the field. This transmission thus enables the driver to be either defensive or offensive in whichever circumstance required. The larger robot features a pneumatic acting lift, which lifts the smaller robot to a height above 12 inches in 2 seconds. Overall, both robots have evolved into top class robots that can perform better than others in competitive environments.



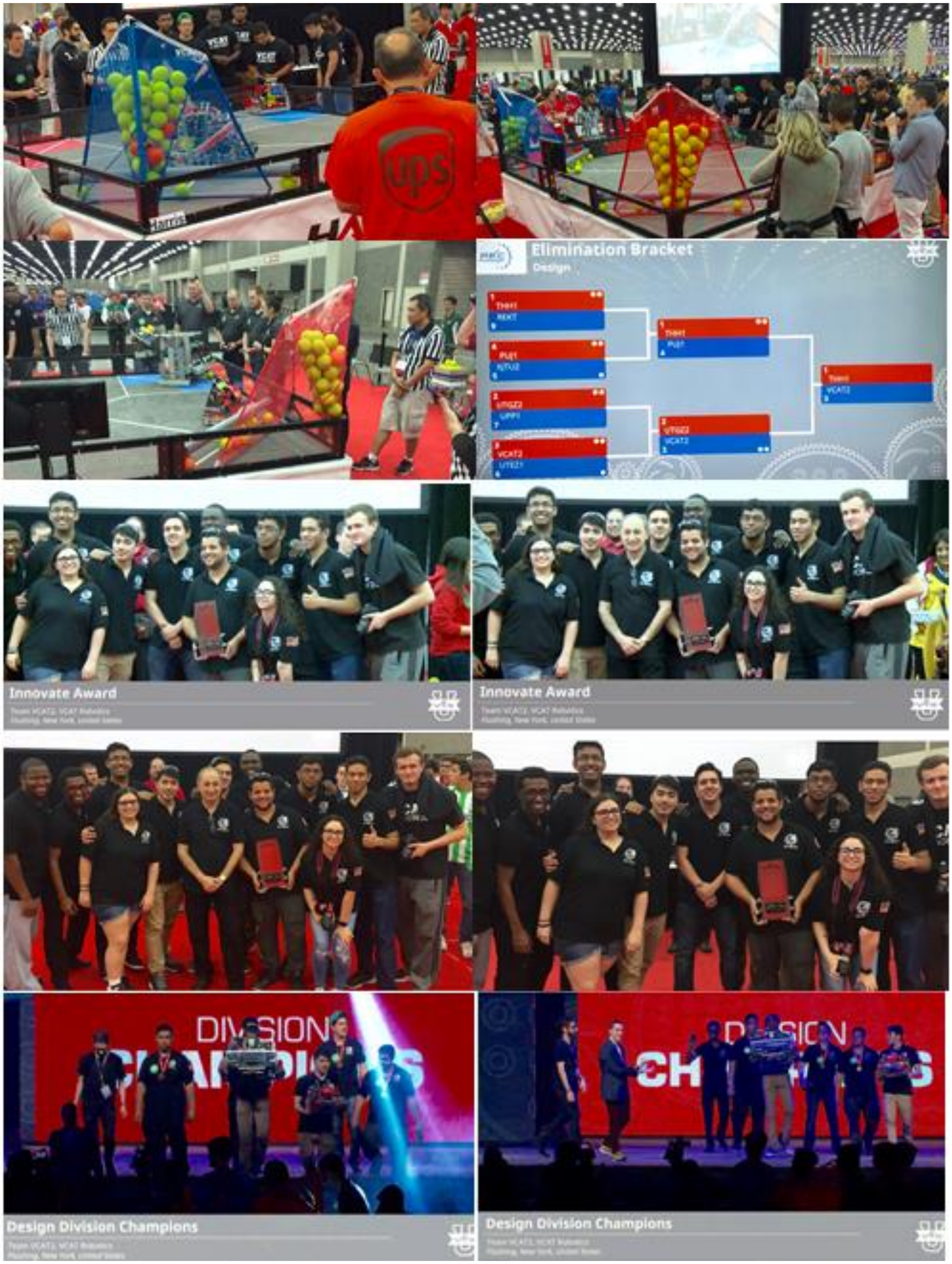
From April 20-23, sixty national and international universities and colleges were invited to the 2016 VEX U World Championship in Louisville, Kentucky Freedom Expo Center. Invitation to the VEX U Robotics World championship is only granted to a tournament champion or regional excellence award recipient team.

The innovative robotics designs with fast launching velocity and advanced autonomous programming, propelled Vaughn's Robotics team into being 2015 tournament champion of the international congress of Technologies of Information and Communication (Cancun, Mexico), tournament champion of the Manchester Community College (MCC) Regional Qualifier, finalist in College of Southern Maryland (CSM) Regional Qualifier, recipient of the Excellence award of Vaughn College Regional Robotics Competition and ultimately, invited participant in the 2016 VEX U World Championship.

At the VEX World Championship, the largest robotics event in the world, the Vaughn team's two innovative robots defeated Mexico's team in the final round, and prior to that win, beat out many US institutions including the University of Southern California, Worcester Polytechnic Institute, and George Mason University, among others. Vaughn's team succeeded throughout this series of competitive matches through its significant implementation of engineering knowledge and skills. Vaughn graduating seniors, including current team president Alex Uquillas and most recent past-president Jefferson Maldonado, along with Terry Cetoute, Kent Ogisu were stars again this year along with their teammates.

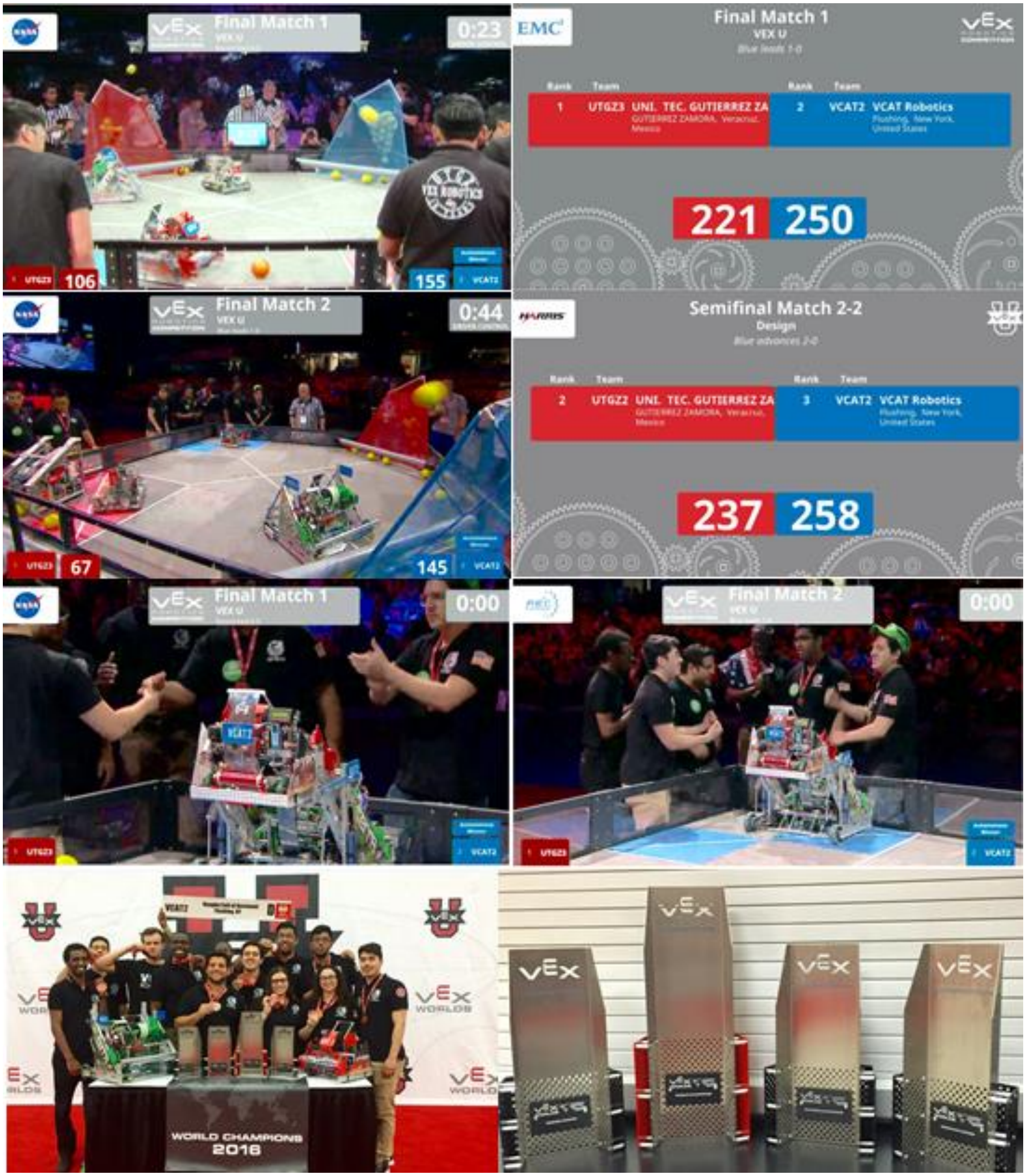
On Saturday, April 23, Vaughn College's Robotics team beat out 60 other college teams to achieve the extraordinary title of World Champions at VEX U. In addition, the team won Design Division Champion Award, as well as the Innovate Award and the Design Award for demonstrating strong ingenuity and innovation in the design of their robots. These additional awards underscore the team's successful creation of engineering design solutions for complex robotic problems. The Vaughn team's discipline, dedication and teamwork ultimately contributed to its attainment of the title "2016 VEX U Robotics World Champion."

This intense three-day competition was challenging, and Vaughn's team developed many autonomous programs in order to be competitive with other top teams in this tournament. Each participating team had a total of 10 matches, and Vaughn's Robotics team won 8 of its 10 matches during the qualification competition that occurred on Thursday, Friday, and Saturday. For the 3rd year in a row, the VCAT robotics team was able to advance to the playoff round of the VEX U World Championship. Vaughn's team defeated all of its competitors during the playoff round and achieved the title for Design division champions of VEX U.



Design Division Champion of 2016 VEX U World Championship

The final matches for the world title between the Design division champion and the Research division champion took place in the dome of the Louisville Freedom Convention Center. Vaughn's robotics team achieved the title of VEX U World Champions by eliminating the Research division champion (UTGZ3, a Mexican team) in the first two matches out of three.



2016 VEX U Robotics World Championship Competition - Vaughn's Robotics Team is 2016 VEX U Robotics World Champion

Mexico's VEX U Reeduca Robotics Competition, November 8-9, 2016

The Vaughn College Robotics team, the champion of 2016 VEX U Robotics world championship, was invited to participate in the Mexico's VEX U Reeduca Robotics competition as part of the **International Congress of Technologies of Information and Communication 2016 (CITIC 2016).** From November 7-9, 35 teams including Vaughn College's Robotics team participated in Mexico's VEX U Starstruck Challenge competition in The Universidad Tecnológica de Querétaro, Queretaro City, Mexico. Six members of Vaughn College's robotic club (Bilal Rashid, Norrin Abreu, Niki Taheri, Eric Grieco, Thomas Wolday, Andriy Belz) and three mentors and advisors Mr. Alex Uquillas (President of 2015-2016 Robotics club), Prof. Khalid Mouaouya, and Dr. Hossein Rahemi represented Vaughn College at this competition.

The intense two days of competitions were challenging; during Tuesday, November 8 qualifying competition, Vaughn's team competed against eight Mexican teams and they won seven out of the eight matches. With seven wins Vaughn's team received automatic qualification for the Wednesday playoff round. During this playoff round, Vaughn's team remained undefeated through the quarterfinals and semifinals and finished first by winning the tournament championship final of this international competition. Vaughn's robotics team members consistently demonstrated persistence and drive in order to attain their title as champions of Mexico's VEX U Robotics competition for two years in a row.

Mexico's VEX U Reeduca International Robotics competition, November 8-9, 2016
Vaughn's Robotics Team wins Tournament Champion

VEX Robotics Fall Scrimmage, Vaughn College, December 10, 2016

Vaughn College hosted a fall practice scrimmage on Saturday December 10, 2016 where teams from four northeast colleges came to Vaughn to hone their skills and strategy before participation in spring regional qualifying matches.

A total of ten teams including New York Institute of Technology, New Jersey Institute of Technology, IFT Robotics, Bergen Community College, and Vaughn College participated in fall scrimmage matches. The event began at 9 am with check-in and robot inspection followed by skill challenges and qualification rounds. "The scrimmage was educational for all participating teams," Rashid said "we learned a lot from the other teams and they learned from us as well."

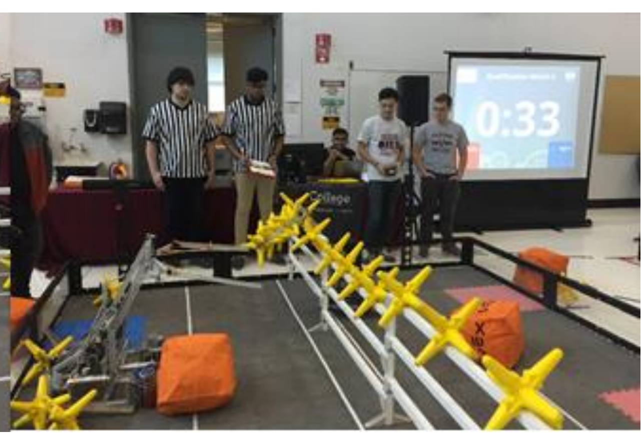
VEX U Robotics Fall Scrimmage, December 10, 2016

Vaughn College hosted VEX U Robotics Regional Qualifier on Friday January 27, 2017
Vaughn's Robotics Team wins 2017 VEX U Excellence Award

Vaughn College of Aeronautics and Technology hosted its Fourth VEX U College Regional Robotics competition on Friday January 27, 2017. A total of ten college teams participated at this event. The participant teams included Adelphi University (ARC), Ivy Labs Education (three teams - IFT, IFR, and IFC), New Jersey Institute of Technology (NJIT), New York Institute of Technology (two teams - NYIT2 and NYIT4), Loyola **University of Maryland** (LOYOL), and Vaughn College of Aeronautics and Technology (two teams – VCAT3 and VCAT4).

Five members of Vaughn College robotic club (Niki Taheri, Eric Grieco, Norris Abreu, Jason Becker, and Juan Aguirre) represented Vaughn teams (VCAT3 and VCAT4) at this competition. Also, Thomas Wolday, Nizamadeen Khedaru, and John Hernandez served as referees, and Bilal Rashid served as the event manager. Harold Gonzalez served as announcer, while Andryi Belz and other team members were involved with setting up the fields and facilitating the implementation process for this event. Two faculty members (Prof. Rodney Dash and Dr. Rex Wong) and four staff members (Mr. Ray Axmacher, Luis Santana, Mr. Frank Wang, and Mr. Celso Alvarez) served as judges for this competition.

During the skills challenge matches, Vaughn's team finished first in Robot Skills (71 points). Each participating team had a total of eight matches. VCAT3 won seven of its eight qualifying matches and VCAT4 won six out of eight matches with both Vaughn teams advancing to the playoff round. During the playoff elimination rounds VCAT4 lost to IFR in the semifinal and VCAT3 defeated all of their opponents thus advancing to the finals where they faced IFR. In an intense final game of tournament matches (best two out of three), VCAT3 won the first match (32 to 17), and due to a damaged power extension VCAT3 lost their last two matches to IFR. VCAT3 team won both the Excellence award (for its engineering notebook, robot skills ranking, and robots design), and the Finalist award. VCAT2 and VCAT3 are now qualified to participate in the 2017 VEX U World Robotics Championship.



VCAT3 wins Vaughn's Regional 2017 VEX U Excellence and Finalists Awards

Vaughn College Hosted VEX High School Robotics Qualifier Competition on Saturday, January 28, 2017

Vaughn College of Aeronautics and Technology hosted its second high school robotics competition on Saturday January 28, 2017. A total of 41 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk counties attended the January state qualifier VEX Robotics Competition at Vaughn College. The list of high school participants is as follows:

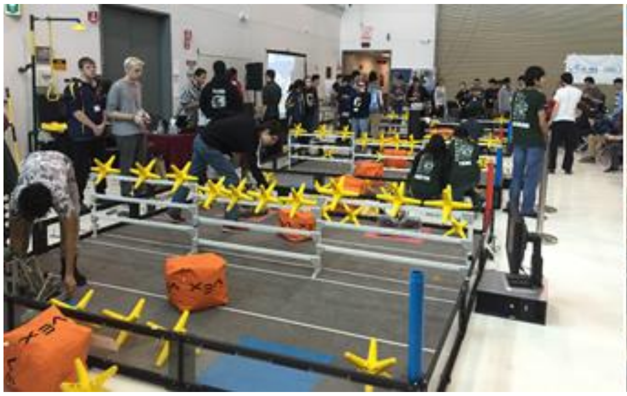
Team List
VCAT VRC QUALIFIER

Team List (41 Teams)

Team	Team Name	Organization	Location
699E	Eve-09	Thomas A. Edison CTE High School	Jamaica, New York, United States
699T	RoboTex	Thomas A. Edison CTE High School	Jamaica, New York, United States
699Z	Andromeda	Thomas A. Edison CTE High School	Jamaica, New York, United States
1312A	ER Rockbots	East Rockaway Schools	East Rockaway, New York, United States
1312B	ER Rockbots	East Rockaway Schools	East Rockaway, New York, United States
1312C	ER Rockbots	East Rockaway Schools	East Rockaway, New York, United States
1353A	Robodalers	Farmingdale High School	Farmingdale, New York, United States
1353B	Dalerbots	Farmingdale High School	Farmingdale, New York, United States
1353C	VEXcalibur	Farmingdale High School	Farmingdale, New York, United States
5059A	FA Robo-Quakers1	Friends Academy	Locust Valley, New York, United States
5059B	FA Robo-Quaker2	Friends Academy	Locust Valley, New York, United States
6277A	RoboCavs	The Harvey School	Katonah, New York, United States
6277B	RoboCavs	The Harvey School	Katonah, New York, United States
6277C	RoboCavs	The Harvey School	Katonah, New York, United States
6277D	RoboCavs	The Harvey School	Katonah, New York, United States
6277E	RoboCavs	The Harvey School	Katonah, New York, United States
7179A	ViKings	Paul D. Schreiber High School	Port Washington, United States
8506A	STEM HS Tesla Titans	STEM HS Academy of Applied Technology	Bellport, New York, United States
8506B	STEM HS Iron Giants	STEM HS Academy of Applied Technology	Bellport, New York, United States
9458	Robo Chiefs	Massapequa School District	Massapequa, New York, United States
9458B	Robo Chiefs	Massapequa School District	Massapequa, New York, United States
9458C	Robo Chiefs	Massapequa School District	Massapequa, New York, United States
9458D	Robo Chiefs	Massapequa School District	Massapequa, New York, United States

9458E	Robo Chiefs	Massapequa School District	Massapequa, New York, United States
9717A	St. Catharine Comets	St. Catharine Academy	Bronx, New York, United States
9717B	St. Catharine Comets	St. Catharine Academy	Bronx, New York, United States
9932A	Hawks	Jericho High School	Jericho, New York, United States
9932B	Hawks	Jericho High School	Jericho, New York, United States
9932C	Hawks	Jericho High School	Jericho, New York, United States
9932D	Hawks	Jericho High School	Jericho, New York, United States
9932E	Hawks	Jericho High School	Jericho, New York, United States
9932F	Hawks	Jericho High School	Jericho, New York, United States
25565A	Seven	Riverdale Country School	New York, New York, United States
25565B	Seven Point One	Riverdale Country School	New York, New York, United States
61112A	Southampton B	Southampton High School	Southampton, New York, United States
61112Z	Southampton A	Southampton High School	Southampton, New York, United States
98046A	Warriors A	Wantagh High School	Wantagh, New York, United States
98046B	Warriors B	Wantagh High School	Wantagh, New York, United States
98456	Robo Frog	St. Mary's Episcopal Church	Carle Place, New York, United States
98570A	Babylon Panthers	Babylon UFSD	Babylon, New York, United States
98570B	Babylon Panthers	Babylon UFSD	Babylon, New York, United States

Members from the VCAT robotics team organized and served as referees for this event. Bilal Rashid served as the event planner and manager; Harold Gonzalez served as announcer. Vaughn faculty members Dr. Shouling He, Dr. Rex Wong, Prof. Khalid Mouaouya, and Prof. Mudassar Minhas and staff members Mr. Celso Alvarez, Mr. Frank Wang and Mr. Luis Santana served as judges for this competition.




The table below provides the list of award recipients for the 2017 Regional High School VEX Robotics State Qualifier Competition. An alliance of the Farmingdale High School and The Harvey School won the tournament championship, while a team from Jericho High School won the Excellence Award. Both tournament champions and Excellence award recipients are qualified to participate in the New York State Vex Championships.

Excellence Award (VRC/VEXU)

9932E	Jericho High School

Qualifies for:
State/Regional Championship
CREATE U.S. Open

Tournament Champions (VRC/VEXU)

1353C	Farmingdale High School
6277B	The Harvey School
1353B	Farmingdale High School

Qualifies for:
State/Regional Championship
CREATE U.S. Open

Innovate Award (VRC/VEXU)

9717A	St. Catharine Academy

Does not qualify for any events.



Create Award (VRC/VEXU)

9932E Jericho High School

Does not qualify for any events.

Build Award (VRC/VEXU)

1353B Farmingdale High School

Does not qualify for any events.

Design Award (VRC/VEXU)

25565A Riverdale Country School

Qualifies for:
State/Regional Championship

Judges Award (VRC/VEXU)

699E Thomas A. Edison CTE High School

Does not qualify for any events.

Tournament Finalists (VRC/VEXU)

9932E Jericho High School

9932F Jericho High School

9932D Jericho High School

Does not qualify for any events.

Robot Skills Winner (VRC/VEXU)

1353A Farmingdale High School

Qualifies for:
State/Regional Championship
CREATE U.S. Open

Energy Award (VRC/VEXU)

699E Thomas A. Edison CTE High School

Does not qualify for any events.

Sportsmanship (VRC/VEXU)

9458C Massapequa School District

High School VEX Robotics State Qualifier Competition, Saturday, February 13, 2016

2017 CSM VEX U Robotics Regional Qualifier Competition, February 3, 2017

On Friday February 3, 2017, Vaughn College's Robotics team participated at the College of Southern Maryland (CSM) VEX U Robotics Regional Tournament. The team was composed of seven sophomores and two freshmen members (Bilal Rashid, Niki Taheri, Eric Grieco, Norris Abreu, Nizamadeen Khedaru, Thomas Wolday, John Hernandez, Jason Becker, and Juan Aguirre) along with department chair, Dr. Hossein Rahemi.

A total of fifteen colleges and universities participated in the event. The participant teams included George Mason University (Mason), two teams from Virginia Tech (TEKVT, VTTEK), two NYIT team (NYIT3 and NYIT5), University of Maryland Baltimore (UMBC), Loyola University of Maryland (LOYOL), two teams from Old Demonian University (ODU and ODU2), two teams from Northern Virginia Community College (NOVA1 and NOVA3), two teams from College of Southern Maryland (CSM &CSM1) and Vaughn College of Aeronautics and Technology (VCAT).

Each participating team had a total of six matches. Vaughn's team won five of its six qualifying matches and advanced into the playoff round. During the playoff elimination rounds VCAT defeated all of their opponents (NYIT, Mason, and CSM) and won tournament champion of this regional competition. The results of the eliminations rounds (best of two out of three) are as follows:

Quarterfinals			Semifinals			Finals		
Match 1	Match 2	Match 3	Match 1	Match 2	Match 3	Match 1	Match 2	Match 3
VCAT **46**	VCAT **43**		VCAT **55**	VCAT **19**	VCAT **21**	VCAT **26**	VCAT **67**	
NYIT3 **6**	NYIT3 **5**		Mason **6**	Mason **23**	Mason **20**	CSM **19**	CSM **1**	

With this win, Vaughn College teams VCAT2, VCAT3, and VCAT qualify for participation in the world championship.

VCAT wins and becomes CSM Regional 2017 VEX U Tournament Champion

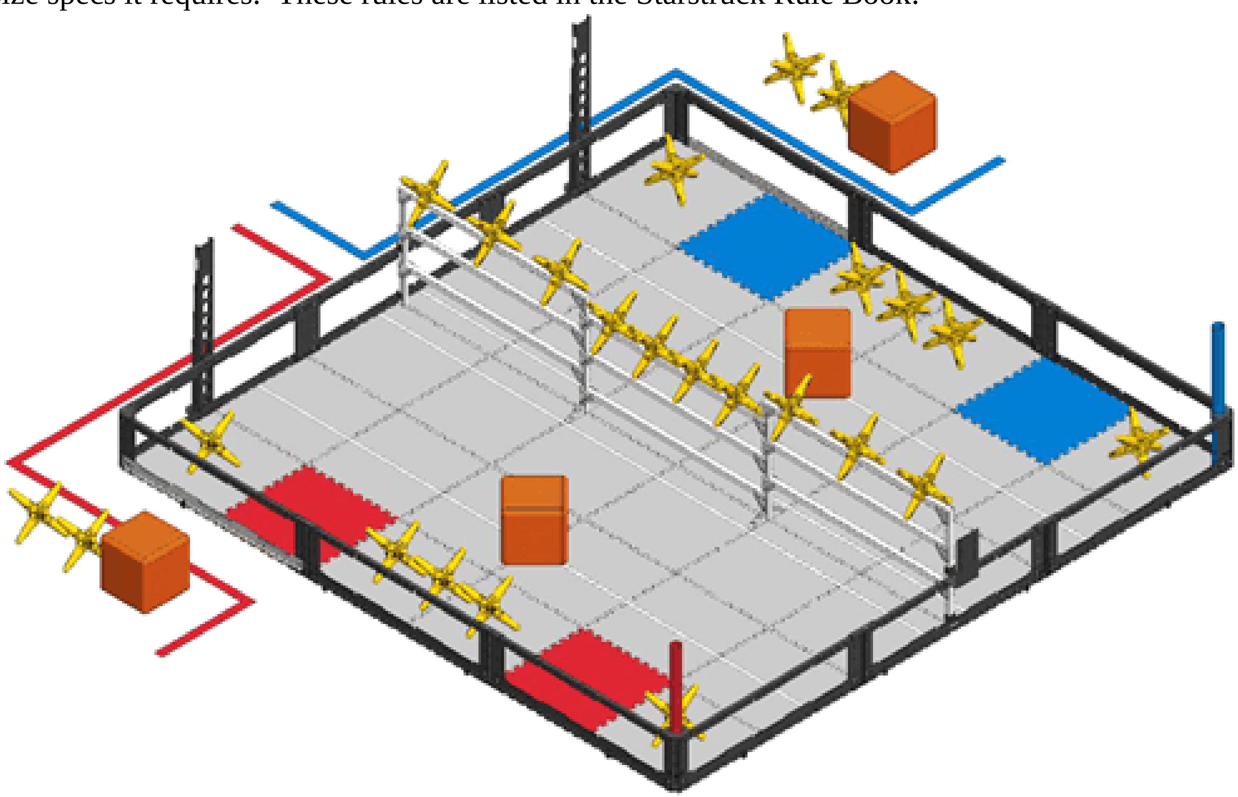
The 2017 Annual Vex College Robotics Competition: Starstruck Game

The VEX Robotics Starstruck Competition is played on a field of 12 ft. x 12 ft. There are 28 game pieces which teams can launch in order to score points. There are two zones on the field into which the pieces can be propelled in order to achieve a scoring point; a near zone closer to the fence, and a far zone closer to the back walls. Teams may also score points by hanging above various heights.

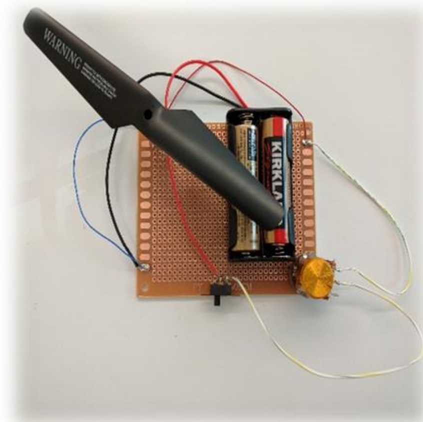
There are two alliances – one "red" and one "blue," but instead of the regular two robots versus two robots (2V2) format, this year the rules have changed to a 1V1 format. These alliances compete in matches consisting of a fifteen second autonomous period followed by one minute and forty-five seconds of a driver-controlled period.

The objective of the game is to attain a higher score than the opposing alliance by scoring stars and cubes into one of the two zones as well as performing a hang. A bonus is also awarded to the alliance that has the most points at the end of the autonomous period.

At the beginning of the match each robot starts off smaller than the 24"x24"x24" cube size limit, but once the match starts the robot can expand outside of the 24"x24"x24" size limitation to any size specs it requires. These rules are listed in the Starstruck Rule Book.



2016-2017 Vaughn's College of Aeronautics and Technology UAV Club Activities



The Unmanned Aerial Vehicle (UAV) club has considerably expanded its member base. This membership expansion increases the club's involvement not only on the Vaughn College campus but also throughout the community. The UAV club focuses both on remote-controlled racing drones and on fully-autonomous drones. Using single board computers like the Raspberry Pi 3 and the NVIDIA Jetson TK1 allows the UAV club to create drones with machine learning capabilities. On October 1 and 2, 2016 members of the UAV club attended The World Maker Faire New York. President Andrew Aquino, Social Activities Director Bobby Tang, and Vice-President Utsav Shah, met with several drone companies including the Flying Squirrels Multirotor, LLC. The members of the club worked towards establishing connections for future events such as International Drone Day 2017 at Vaughn College. At Maker Faire, the club members also attended a talk by Matt Richardson on the Raspberry Pi and many other available computer projects. Additionally, the club spoke to many companies displaying drone application and technology projects.

On October 28, 2016, several members of the UAV club organized a workshop at the 2nd Annual Manufacturing Day Conference at Vaughn College. The workshop entitled, "Learn to Design and Build a Drone" introduced basic principles concerning drones, including the operation of the many different components. In the workshop, students learned about drone applications, types of drones, and the design and construction of drones.

In addition to this presentation, students participated in hands-on activities such as building a speed controller simulator. In building the simulator, students learned the fundamentals of soldering and practiced soldering resistors, wires, and potentiometers. As students completed their simulators, they were invited to the hangar where they could fly racing drones in the netted area. Club members, Andrew Aquino, Bobby Tang, and Utsav Shah taught this workshop.

In addition, on December 10, 2016, the UAV club organized the workshop, "Discover the Skies" as a part of the Next Gen Stem Girl Scouts event. This workshop included a quick presentation about drones, a speed controller simulator workshop, and a free flight event at the Vaughn College hangar. At the end of the workshop, students could keep the speed controller simulator circuit they had built. A total of three sessions of the workshop were held with more than 40 girl scouts in attendance.

The Vaughn College UAV club members, Andrew Aquino, Bobby Tang, Utsav Shah, and Daniel Khodos developed a paper entitled, “Self-Designed Drone as a Platform for Engineering Education.” Under the mentorship of Dr. Shouling He and Dr. Amir Elzawawy, the paper was submitted to the Institute of Electrical and Electronics Engineers (IEEE) Integrated STEM Education Conference (ISEC) 2017.

The paper describes an educational approach that uses the development of a drone system as a teaching and learning platform to introduce engineering concepts. These concepts include an explanation of the working principles of components used to build a drone, computer aid design and 3D printing of the drone frame, drone software and control algorithm development, as well as system integration design for the drone. The targeted learners are primarily STEM students in middle and high school, as well as drone hobbyists who are interested in systems and engineering designs. This educational design approach has been employed in the education of students and drone hobbyists during several workshops on International Drone Day and Manufacturing Day at Vaughn College of Aeronautics and Technology. The workshop assessment results demonstrate great promise not only in terms of improved learning in drone design among middle and high school students and hobbyists, but also in terms of providing a valuable experience for the Vaughn College UAV (Unmanned Aerial Vehicle) club members. Through these workshops students learn how to develop the educational hardware and software platform for experimentation with flying robots and graphics design and animation. Students also learn how to develop an algorithm for a UAV control system.

The UAV club is also collaborating with the Cradle of Aviation Museum, located in Garden City, New York. The museum is using drones as a platform for engineering education. Teachers from many Long Island school districts will bring their middle school students to participate at these events. The first event was held on January 16th, 2017 where students and teachers were invited to the museum in order to take part in drone discussions, watch drone flying demonstrations, participate in workshops, and speak to experts on drone technology. The UAV club hosted the "Learn to Build a Speed Controller" workshop, where participants were taught how to make a manual representation of a speed controller, which is an essential component for every drone.

On February 18th, 2017 at the Professional Development workshop, teachers received hands-on training in drone theory, construction, flight controller configuration, troubleshooting and flying. The UAV club demonstrated to middle-school teachers how to build a FLYBRIX drone. It is essential that these teachers themselves become comfortable with drones, so that they may better assist their middle school students in building their own drones.

On March 25th, 2017 middle school students from all over Long Island were asked to participate in a STEM drone competition. The students employed physics and engineering principles, as well as teamwork to build and fly their own drones. They also learned how to while solve real-world problems using drones in their communities. The students used the drone they created to complete a variety of tasks in the course. These events are an exciting way to get middle school students involved in the future of aerospace technology, while they work collaboratively on projects involving hands-on learning.

The UAV club is planning to participate and compete in the American Helicopter Society (AHS) 5th Annual Micro Air Vehicle (MAV) Student Challenge. The purpose of this competition is to execute target "search and retrieval" obstacle avoidance and return to a base station using only onboard sensors and cameras. There will be two targets, as well as a wall-like obstacle between the base and the target search area. The MAV must first carry an envelope to its first location which the MAV must find on its own. Then the vehicle must deliver the package to the first location, while locating the next target on its own. After locating the second target the drone must pick up the second package and return to the base while avoiding the wall-like obstacle. As each task is completed, the team is awarded points. Teams that participate in the competition may choose to design either a remotely-controlled system or a fully-autonomous system. The UAV club will be sending two teams to participate in the competition, one with a manual drone and one with an autonomous drone. The team captain of the autonomous team will be Andrew Aquino, president of the UAV club, and the team captain of the manual team will be Bobby Tang e-board member of the UAV club. To participate in the competition, teams must get approval for their submissions through Gate 1 and Gate 2. Gate 1 is a paper submission of a 5-page abstract which identifies the key students and faculty members who are involved, the vehicle specifications and capabilities, the onboard systems and remote operation development proposal, and the preliminary plan.

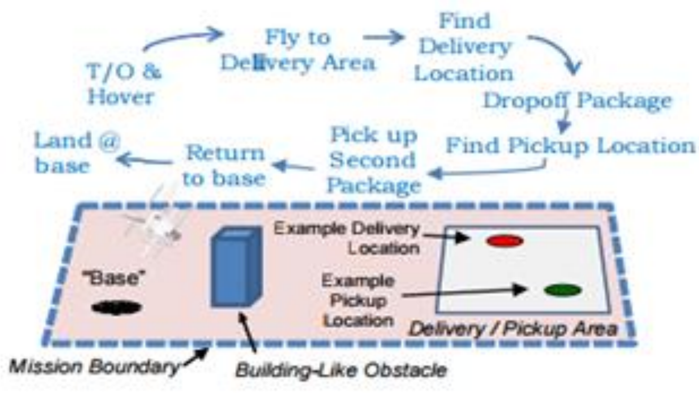


Figure 2. Task B - Target Search Mission

Task B/ Mission Phase	Qualitative Criteria	Rating ID (0-5)
Take off & Hover	2 m (6 ft) hover height above base. Metrics: Time to stable hover & Hover stability.	Q1
En Route to Delivery/Pickup Area	Transition to this phase with clearly-announced user signal. Metrics: Qualitative smoothness of transitions and Time to reach delivery area.	Q2
Obstacle Avoidance	Avoid obstacles between the home base and the target search area. Metrics: Successful avoidance, Smoothness of flight around obstacles.	Q3
Target Search	Remote operator or Autonomous system will use only onboard camera to find each target. Metrics: Time to find target, Operator involvement	Q4
Target Acquisition	Establish a stable hover for at least 5 seconds over each delivery/pickup location target. Smoothly transition between searching, hover, and dropoff/pickup. Metrics: Lateral target tracking error, Stable roll/pitch performance	Q5
En Route Return to Base	Transition to this phase with user signal. Remote operator can use LOS. "Base" can use homing beacons for autonomous RTB. Metrics: Qualitative smoothness of transitions, Time to acquire stable hover over base	Q6
Hover and Landing	Acquire stable hover 2 m (6 ft) above base before landing. Metrics: Hover and landing performance, distance from center.	Q7

This paper was submitted and approved on January 20, 2017. The Gate 2 submission due date was March 17, 2017 and teams provided video evidence of competition readiness. Teams must also submit final vehicle and system configuration descriptions and vehicle autonomy and report operation capabilities including target tracking results. The video must clearly demonstrate the dimension and weight of the vehicle and stable hovering over a known target using onboard vision.

The UAV club plans to host the 2nd Annual Vaughn College International Drone Day event on May 6, 2017. The event will include a free flight event in the hangar, several engineering workshops about drones, and a guest panelist discussion about drones. The Vaughn College UAV club is currently working on creating partnerships with drone companies as well as exploring the possibility of establishing booths for drone companies at the event. One of the companies the club is currently working to establish at the event is DJI- USA. The mission of this event is to celebrate all the possibilities of drone applications.

Engineers Without Borders (EWB) Club Activities

ENGINEERS WITHOUT BORDERS-US
VaughnCollege

Engineers Without Borders (EWB) is a global organization that works to create a better world through engineering projects which provide communities with the help they need to stand on their own and to fly to new heights. Volunteers and professional engineers alike work to meet this vision by finding solutions to issues such as water supply, sanitation, energy, agriculture, civil works, and infrastructure.

The Vaughn College Chapter of Engineers Without Borders-USA (VCAT EWB) was established in November 2015. With a brand new chapter room (located in W152A) and a growing number of new members joining every semester, the chapter is gradually handling ever larger projects and it eventually plans to work on international ventures.

Octoberfest

In October of 2016, the chapter collaborated with other clubs to create an inter-college festival called Octoberfest. Octoberfest is a week of daily events hosted by different clubs and chapters to celebrate the coming of Halloween. VCAT EWB helped organize and manage two events during the Octoberfest: "Amateur Night at Vaughn College" and "Video-Gaming Competition". Collaboration with other clubs contributes to the growth and future efficiency of VCAT - EWB. This association with other clubs further allows our chapter to foresee problems that could occur within future community projects.

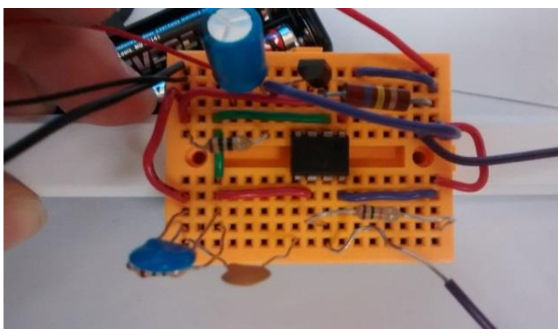
Boston Conference

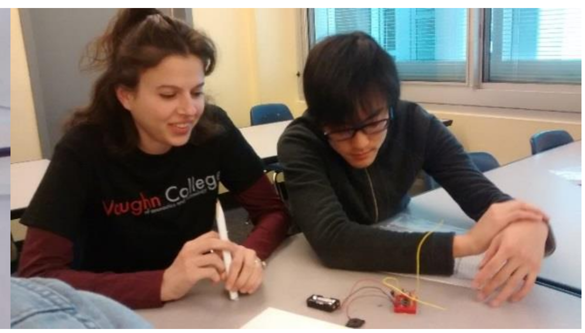
On November 4^{th} – 6^{th}, 2016 the Northeastern Conference for the EWB – USA student and professional chapters was situated in Boston University. Our chapter sent a few of our members to listen and learn from other chapters and professional engineers about the projects and ideas they have. At this conference we learned about different tools we can access such as Volunteer Village and Chatter. The members also attended several lectures through which they learned from the experiences of other professional chapters. These lectures shed light on the intricacies of projects once they have passed the survey phase.

Theremin Workshop “Musical Sense”

The purpose of this workshop held on December 5, 2016 was to educate children about the STEM fields through the use of circuitry to create a musical instrument called a Theremin. The Theremin works by having the user connect two lead wires of the circuit to a conductive material to complete the circuit and allow the flow of current. Based on the material’s resistance, the pitch of the sound created by the Theremin will vary, thus allowing the user to play different musical notes. The children were first introduced to basic electronic and electricity concepts, such as resistors, capacitors, integrated circuit chips, and transistors. Afterwards, audience members were each handed an individual kit including a breadboard to make the circuit and all the necessary components, including a completed instructional diagram, for the creation of the Theremin circuit. Additionally, every child who entered the workshop left with a completed circuit, regardless of whether or not they were able to complete this process on their own. The workshop was considered a success based on the excitement level of the children who worked hands-on with the electrical components and on the survey feedback they provided.

The Theremin workshop was considered successful enough for us to host it again for high-schoolers on February 25th, 2017.





Burritos without Borders

This fundraiser held on December 8’ 2016 was a collaboration with VCAT – EWB and a Chipotle restaurant in the vicinity of Vaughn College. Our part was to facilitate delivery and transportation between the college and the Chipotle restaurant. Anyone who went to Chipotle and mentioned our name had a portion of their funds spent on this food sent to VCAT - EWB as a donation. Cooperation and organization were necessary components of this fundraiser, because members had to travel between locations and to deliver food back to the college while keeping track of which person ordered which dish. This collaborative process helped members to develop both trust and teamwork skills.

Valentines Sale February 14th, 2017

As a team, Charles and Hermes agreed to the concept of recordable Valentine’s Day cards. They decided to order instead of create the modules in order to save time and money. The fundraiser was a huge success for VCAT – EWB, especially because of the sense of cooperation fostered between the chapter members.

Boot Camp, February 3, 2017

One of the programs our chapter adopted from the Boston conference was Boot Camp. Since we had no experience of our own on which to base our Boot Camp, Christian, a member of VCAT - EWB, contacted a member from the northeastern chapter whom we had met at the Boston Conference, and the chapter provided us with basic information on how to run a boot camp. Jamal and Christian used the guidelines and adapted them to align with the project we had in mind. They created a presentation using walkie-talkies and medical, water quality, and survey equipment. Our Boot Camp enabled us to recruit two new members and to enrich our current members' knowledge regarding the initiation of new projects.

Leadership Workshops

In order to recruit and train members for future executive board positions, current members Tobi Alade, Cae Chow, and Sam Maddaloni developed and hosted a three-session Leadership Series. The series covered many topics including project management, delegation, time management, and public speaking. The first session described the administrative structure of EWB-USA from Headquarters to the Vaughn Chapter and introduced leadership opportunities available to members of the Vaughn Chapter. Andrea O'Neill, the Manager of Institutional Events, was featured as a guest speaker during the second leadership session and she discussed best practices for event planning on campus. For the final leadership session, Dr. Sharon Devivo, the Vaughn College President, joined the members in discussing public speaking and presentation skills. The students were immersed in an interactive learning session and heard valuable strategies from the President. "We received very positive feedback from both the attending members and our amazing guest speakers. We were able to encourage nine students to run for executive board positions, so I see it as a huge success. We plan to expand on this series in the years to come," says Sam Maddaloni, one of the collaborators of the series.

The Future: Possible Project in Nicaragua

Our chapter has participated in college and local events and is now ready to move onto larger goals. As aligned with the goals of EWB, we looked for our first undertaking, and we settled on a water project in Nicaragua. Vaughn College gave us the green light, and now we are waiting for Adam Brostow, the mentor of VCAT - EWB, to provide his endorsement.

SWE Club Activities

Since the summer of 2015, the Vaughn College Chapter of the Society of Women Engineers has voluntarily organized a number of workshops to help middle and high-school female students understand the field of engineering. Our chapter has also encouraged more girls to pursue an engineering career. Vaughn Chapter members have further pledged to write and present educational research papers at future conferences.

After the demonstration workshop entitled "Wearable Electronic Workshop – Enhancing the Interest and Participation of Underrepresented Female Students in Engineering," conducted by the Vaughn Chapter at the IEEE WIE Summit USA East in Philadelphia, PA from November 6 to November 8, 2015, Dimitri Papagzoglou, President of the VCAT-SWE Chapter and Saneela Rabbani, past Secretary, along with the Chapter's advisor, Dr. Schuling He, presented a paper at this highly successful workshop. The paper "Create Interests in Engineering with Girl Scouts," taught middle and high school girls how to build a simple electric piano using basic electrical components. It was presented at the 2016 ASEE St. Lawrence Conference at Cornell University in April, 2016. Conference attendees lauded the presentation and recommended it to the journal's editor for publication. "Transactions on Techniques in STEM Education" was published in the journal's July-September issue. The journal's chief editor later informed the authors that the paper was selected as the best one written for the journal and this article received "Best Paper" award.

SWE STEM Outreach

During the fall of 2016, VCAT- SWE hosted three STEM outreach workshops. The purpose of the workshops was to introduce students from K to 12^{th} grade to the world of STEM by showcasing fun products to construct using a theoretical background. The first workshop was entitled the Worm Workshop. It was held on November 18, 2016 and students were taught how to build a simple robot. In addition, they learned about DC motors and Lithium polymer batteries.

On December 2^{nd}, 2016 VCAT- SWE Chapter members visited the Clara H. Carlson Elementary School where they taught students how to build an Electric Breadboard Piano. VCAT- SWE member, Samantha Maddaloni, chaired the workshop. Two one-hour sessions were held, with 5^{th} and 6^{th} grade boys also in attendance. Students were taught the fundamentals of current and voltage, as well as how to use resistors, capacitors, and switches. After learning the basics, the students were given step-by-step instructions on how to build their own piano. This hands-on process allowed the girls and boys to better understand what had been previously demonstrated. The workshop also promoted teamwork and problem-solving skills. The Breadboard Piano workshop established a relaxed learning environment for both students and staff members, which fostered creativity during the exploration of various engineering techniques.

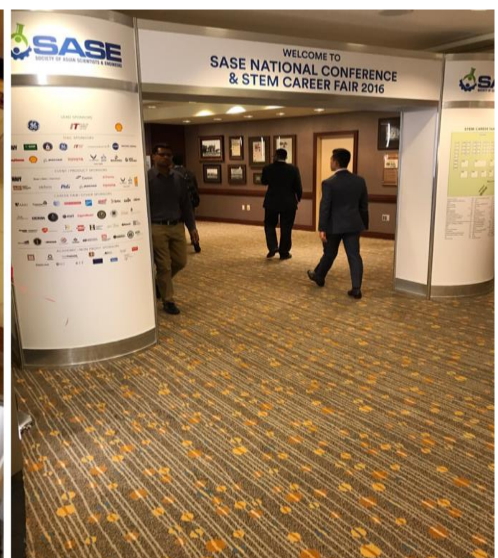
The last workshop was held on December $10^{th,}$ for STEM Day. Girl scouts from all across the New York area were exposed to various STEM activities. VCAT- SWE members created a Maglev train and held a STEM Day workshop with their new creation. Both the Worm Workshop and the Maglev train were presented in collaboration with the Upward Bound Program. The girls learned about the positive and negative forces of magnets and how the Maglev technology has been and will be incorporated into future creations. They also built their own cars and raced them down SWE’s Maglev rails. It was a fun and creative workshop that helped the students understand basic mechanical engineering concepts.

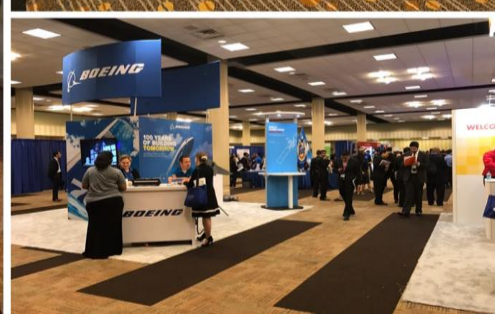

SOCIETY OF ASIAN SCIENTISTS AND ENGINEERS NATIONAL CONFERENCE AND CAREER FAIR IN DALLAS, OCTOBER 14-16, 2016

The Society of Asian Scientists and Engineers (SASE) hosted its 2016 National Conference and Career Fair at the Dallas Hyatt Regency in Dallas, Texas from October 14-16. The purpose of this event was to provide a platform for students to discover their leadership potential and expand their education and career paths. Close to 2,000 students and professionals were in attendance from across the United States. Every year, the National Conference and Career Fair supports SASE's mission to advance personal growth and careers for Asian heritage students and professionals in the engineering and science fields.

On October 15, the Society of Asian Scientists & Engineers (SASE) hosted a career fair where many recruiting companies and government organizations were present and actively seeking internship candidates in various engineering fields.

Three Vaughn College students (Darwing Espinal, Nicolas Ceballos, and Damian Gaona) from the college's engineering and technology department attended the career fair at the Dallas Hyatt Regency. Students met and interviewed many industry leaders and government agencies such as Lockheed Martin, Boeing, Northrop Grumman, United Technologies, Raytheon, NASA, and Toyota among others. Attending SASE's National Conference was a great opportunity for Vaughn's students, and their participation instilled them with confidence, since they all had the opportunity to discuss their technical and academic credentials with potential employers.





National Science Foundation Grant

For the past four years, the National Science Foundation ($575,000 NSF grant "Increasing Student Enrollment and Achievement in Engineering and Engineering Technology,") scholarship recipients were enabled to participate in several in-class and out-of-class activities which contributed to their attainment of the project's goals. Also, these NSF supported learning communities provided these participants with skills hands-on, problem solving, programming, teamwork and communication skills, ultimately providing them with a greater appreciation for their engineering education.

These learning communities, regional, national, and international conference attendance, and paper, poster, and robotics competition sessions all reinforce the learning outcomes of the NSF grant. Vaughn STEM scholarship recipients received top place in these competitions (2014-2015 NSF APR and 2015-16 NSF Students' Accomplishment). As one example, on April 20-23 of last year, among the sixty national and international universities and colleges invited (all tournament champions of their regions) to participate in the 2016 VEX U World Championship in Louisville, Kentucky at the Freedom Expo Center, Vaughn's team finished first, winning the Innovate award, Design award, the Design Division tournament championship and the VEX U World Tournament Championship. Also, the team's Engineering Notebook is published by the **Robotics Education and Competition Foundation (RECF) as an example for other teams to follow.**

Students who are awarded these scholarships have the opportunity to work one-on-one with a faculty mentor to explore their research interests. The quality of these research relationships adds significantly to the depth of each recipient's educational experience at Vaughn.

NSF Scholarships in STEM Fields: Cohort II (senior students)

Even though NSF learning communities have many participants, due to selection criteria requirements (Minimum 3.00 GPA and financial aid eligibility), only 10 senior students are eligible to receive NSF scholarships. NSF scholars are required to participate in the following out-of-class activities:

1. NSF group monthly meeting with faculty mentors
2. Engineering and Industry Connection Seminar Series
3. Work sessions with faculty mentors to develop projects for Vaughn's Tech Day NSF poster competition.
3. Robotics, UAV, SWE, and EWB Clubs and activities
5. National and international student paper/poster competitions.
6. Robotics and UAV Competitions
7. Industry field trips

The senior NSF scholars are encouraged by their advisors to participate in professional development and scholarly activities which enhance innovation. Some of these activities are as follows:

1. All NSF scholarship recipients participated in 2016 Vaughn College Technology Day Conference (April 28, 2016) and presented their technical projects to students, faculty, and advisory members during the afternoon NSF poster session at this conference. A poster entitled "Designing a Universal Allen Key to Optimize Work Efficiency" by

Nicholas Kumia and Bobby Tang was selected by industry advisory members as the recipient of the first place award of this competition.

2. Four NSF students, Saneela Rabbani, Josiah D'Arrigo, Nicholas Kumia, Jonathan Zubarriain, presented their NSF projects (Project 1. **Design and Implementation of a Braille clock** by Saneela Rabbani and Josiah D'Arrigo, and Project 2. **A low Cost Automated Pill Dispenser for Home Use by** Nicholas Kumia, Jonathan Zubarriain) during the Maker Event session of ASEE Annual Conference in in New Orleans, Louisiana, June 26-29, 2016. Their projects were selected as finalists for the ASEE Design and Manufacturing division competition. The student project entitled "**Design and Implementation of a Braille clock"** by Saneela Rabbani and Josiah D'Arrigo received the 2nd place award of 2016 ASEE Manufacturing Student Division Competition.
3. Three NSF scholarship recipients Kent Ogisu, Terry Cetoute, and Alex Uquillas (president of Vaughn Robotics club), participated in the 2016 VEX U World Championship Competition in Louisville, Kentucky Freedom Expo Center. From April 20-23, among the fifty nine national and international universities and colleges invited to the 2016 VEX U World Championship, Vaughn's team finished first, winning the Innovate award, Design award, and the Design Division tournament championship, ultimately becoming the VEX U World Tournament Champions.
4. Two NSF students, Nicholas Kumia and Bobby Tang, participated in the Latin American and Caribbean Consortium of Engineering Institutions - LACCEI2016 Conference, and presented their NSF research project "“**Engineering a Universal Hex Key to Optimize Work Efficiency,"** during the student poster session of LACCEI2016, San Jose, Costa Rica, July 19-22, 2016.
5. Five NSF scholars, Saneela Rabbani, Nicholas Kumia, Bobby Tang, Vincent Cuneo, and Jonathan Zubarrian, have plans to organize a day of drone workshops related to Arduino Programming, CAD Modeling of Quadcopters, and Learn to Build a Drone on Saturday May 7 in order to celebrate International Drone day. The event allows participants (visitors and students) to design, build, and test their own drones in the netted flying arena in the college hangar.
6. Five NSF scholars (Nicholas Kumia, Jonathan Zubarriain, Bobby Tang, Andrew Aquino, and Wassem Hussain) participated in Vaughn's International Drone Day on Saturday, May 7, 2016 by hosting drone workshops on Arduino Programming, CAD Modeling of Quadcopters, and Building a Drone, in the Vaughn hangar flying arena.
7. Four NSF scholars (Nicholas Kumia, Bobby Tang, Wassem Hussain, Andrew Aquino) participated as finalists in the autonomous category of the American Helicopter Society (AHS) International's Annual Micro Air Vehicle (MAV) competition on May 16, 2016, in West Palm Beach Convention Center, Florida.
8. Three NSF scholars from Vaughn's UAV club (Bobby Tang, Andrew Aquino, and Wassem Hussain) participated in Vaughn's 2nd Annual Manufacturing Day Conference and hosted a STEM workshop on learning how to build a drone along with a drone flying session in Vaughn's hangar on Friday October 28, 2016. The participants for the

workshops and drone flying session were students from Freeport, Bayside, and Thomas Edison high schools.

9. From 2016 to the present, four NSF scholars from Vaughn’s UAV club (Bobby Tang, Andrew Aquino, Wassem Hussain, and Vincent Cuneo) assist in a UAV workshop at the Cradle of Aviation Museum competition for middle school and high school students.
10. All NSF scholarship recipients are planning to participate in the 2017 Vaughn College Technology Day Conference on April 27, and to present their technical projects to students, faculty, and advisory members during the conference’s afternoon poster session. The following are a list of NSF STEM Scholarship Research Activities that will be presented during the Eighth Annual Technology Day Conference on Thursday April 27, 2017.
    - “On Comparison of Modeling of Electrical and Mechanical Systems– Part II, Wilberforce’s spring” by Denis Nekrasov.
      Advisors: Drs. Shouling He and Dr. Paul LaVergne
    - “Application of a Moving Surface Boundary-Layer Control” by David Adegbesan and Oliver Khairallah. Advisor: Dr. Amir Elzawawy
    - “Smart Child-Proof Medical Container” by Bobby Tang and Vincent Cuneo.
      Advisor: Dr. Youngshwar Budhoo
    - “Increasing Airfoil Performance with the use of a Moving Airfoil Surface Mechanism” by Jamal Sharifi and Ahmed Elshabrawi.
      Advisor: Dr. Amir Elzawawy

NSF Scholars involvement in UAV project

NSF Scholars involvement in STEM Workshop (How to build a drone)

NSF Scholars involvement in Conferences - Student Paper and Poster Competitions

List of 2015-2016 Placement Activity

The following table provides graduates' career placement statistics within the engineering and technology department for the 2015-2016 calendar years. This can be used as an indicator to evaluate the effectiveness of the program in producing graduates who are sought by the general engineering industry and graduate schools. During the academic year 2015-2016, our students obtained internships and accepted employment at several corporations, including Sikorsky Aircraft, Pratt and Whiney, RCM Technology, Arcbest Technology, Safe Flight Instruments, Cox & Company, Cyient, and many others. These corporations have employed our graduates as mechanical engineers, design engineers, mechatronics engineers, control engineers, structural engineers, avionics engineers, and project engineers. The department of engineering and technology views such placements as a strong indicator of our students' value to the industry and of our programs' success in meeting our objectives..

Student Name	**Program**	**Internship**	**Industry**	**Graduate School**
Josiah D'Arrigo	Mechatronic Eng.		UL	
Christopher Chariah	Mechatronic Eng.		Contract Pharmacal Corp. (CPC)	
Bryan Cook-O'Rielly	Mechatronic Eng.		Cyient - Pratt and Whiney	
Zechariah Gajadhar	Mechatronic Eng.		PLX Inc.	
Terry Cetoute	Mechatronic Eng.		Toyoda Machinery USA	
Anjali Vijay Dhobale	Mechatronic Eng.			MS in ME at Penn State
Raquel Torres Gonzalez	Mechatronic Eng.		RCM Technologies	
Kent Ogisu	Mechatronic Eng.		RCM Technologies	
Terry Beesoon	Mechatronic Eng.		GEP Worldwide	
Kevin Alarcon	Mechatronic Eng.		Itron	
Jonathan Zubarriain	Mechatronic Eng.		Cox and Company	
William Dale	Mechatronic Eng.		Pawling Engineered Products, Inc.	
Jefferson Maldonado	Mechatronic Eng.		Arcbest Technology - R&D branch of Arcbest Corporation	
Milana Natanova	Mechatronic Eng.		Cyient – April 2017	
Monica Vantepool	Mechatronic Eng.	Toyota-Spring 2016		
Daniel Khodos	Mechatronic Eng.	SciMax Technologies, Sumer 2016 & 17		
Dimitri Papazoglou	Mechatronic Eng.	DOE, Pacific Northwest National Laboratory-Summer 2016		
Emily German	Mechatronic Eng.	Daimler Summer 2017		
Betsy Sanchez	Mechatronic Eng.	Toyota-Spring 2017		
Lovedeep Kaur	Mechatronic Eng.	John Deere-Summer 2017		
Olivia Hyman	Mechatronic Eng.	NASA-MUREP, 2014-16 Ames Research Center, Mountain View, CA		
Saneela Rabbani	Mechatronic Eng.	Pall Corp., Fall 2015 DOE, ORNL Summer 2016		
Wasif Iqbal	MET		Pratt and Whiney	

Vincent Collucci	MET		Cyient	
Nelson DeMatos	MET		Cyient	
Samantha Bux	MET		Cyient	
Sean Tyrrell			Cyient	
Muhammad Noman	MET		Sikorsky Aircraft	
Cannon Patel	MET		DataForm Software, Inc.	
Gazi Hafiz	MET		RCM Technologies	
Alexis Trotter	MET		RCM Technologies	
Andel Clemmings	MET		Cyient	
Shaun Spiteri	MET		Cyient	
Moussa Kone	MET		Cyient	
Mohamed Haridi	MET		RCM Technology	
Cesar A. Revelo	MET		RCM Technology	
Mohamnmed Ayoub	MET		Cyient	
Ajish Mathew	MET	NASA - (MUREP) Marshall Space Flight, Alabama	Sikorsky Aircraft	
Ceballos, Nicolas F		SciMax Technologies-2016		
Jessica Jemenz	MET	Raytheon – Summer 2017		
Darwing E. Mota	MET	Exelon – Summer 2017		
Espinal Mota, Darwing Emmanuel		SciMax Technologies-2016		
Snayder Arellano	MET		RCM Technology	
Kevin McConkey	MET		Total Technical Services	
Valiantsin Zakhvatkin	MET		ADE System Inc. HVAC Engineer	
Anaid Torres Ortiz	MET	Venture Aerobearings		
Jonathan Shakhmoroff	MET	SciMax Technologies	Cox and Company	
Kazi Ahemed			Cox and Company	
Elias Paulino	MET		Butler America	
Rahul Sharma	MET		United States Air Force	
Desborn Myle	AAS-Aero		U.S. Navy/	
William Yim	MET		Cyient	
Simcha BEST	MET			MS in ME at CUNY
Bismark Opoku	MET		Paul Smith	
Moubarak Agoro	MET		SUNY Canton	
Demitri Fraser	MET		Magellan Aerospace	
Iheanyi Ezekiel	MET		Cyient	
Damian Gaona	MET	Composite Prototyping Center (CPC)		
Guillermo Bacha	MET	FAA	Cyient	
Vishal Bhosale	AAS Aeronautics		Amazon Robbinsville	
Elvis Moricete	MET		Time Warner Cable	
Jason Greene	EET		Safe Flight Instrument Corp.	
Hilain Hector	EET		Safe Flight Instrument Corp.	
Syed Hassan Ali Mousavi	EET-Avionics		Piedmont Airlines	
Sylvon Cabose Jr.	EET-Avionics		DCMA – Quality Assurance	
Alton Taylor	EET		FAA	
Vijay Singh	EET		G.A.L. Manufacturing Corp.	

Sheikh Moiz Haq	EET		Swiss International Airline, LTD	
Eric Leon	EET		Spectrex Inc.	
Noah Argaw	AAS-Avionics		Magellan Aerospace	
Joshua Matias	AAS-Avionics		Safe Flight Instrument Corp.	
Farhana Hossain	AAS-Avionics		Delta Global Services	
Karim Fadel	EET		Piedmont Airlines	
FNU Mohammed Furqhan Ahmed	EET		Piedmont Airlines	
Spencer Boakye	EET		Alliance Security	
Cliff Kennedy	EET		American Airlines	
Anthony Biondo	EET			MS in EE at CUNY
Daniel Grant	Digital Animation & Technology	Women's Venture Fund		

Flip and Stow

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Abstract

The aim of this project is to create a table top surface that can be added to an existing wheel chair and also be sturdy enough for a college student to use on a daily basis. The table must be able to hold the weight of a few text books, and it must also be large enough for a student to comfortably perform work. The table will fold out of the way to facilitate placement in a vehicle, and it must not inhibit the wheel chair's operational capacity. A further goal is for the table to have an adjustable height and to be adaptable to any wheel chair, making it ideal for additional activities other than doing homework.

1. Introduction

The idea for this project came from Michael's brother, Brandon Dewitt, who suffers from a condition known as HSP (Hereditary Spastic Paraparesis). HSP is a condition in which the signal from the brain to the lower extremities has an impaired transmission. This impaired signal causes lower back pain and decreased mobility. In spite of this condition, Brandon is currently attending college and excelling in his courses. When considering ideas for this project, Michael asked his brother one very basic question, "What would be the biggest and most useful change to your wheel chair?" He replied simply, "A table I could use to do my school work." Since the table would be used in conjunction with the wheel chair the best idea was to attach the two. The issue with most add-on tables is that they are made of cheap lightweight materials, as shown in Figure 1, that would not stand up to the heavy demands of a college student.

Figure 1: Table Attached to Wheelchair [1] **Figure 2: Wheelchair with Small Table [2]**

Tables made of heavy materials are not usually compatible with wheelchairs; users are thus forced to rely on others to carry the table separately, thus limiting the usefulness of this device.

A folding table is observed in Figure 2; these are very small, and they do not provide enough comfortable work space. One advantage of these foldable tables is their light-weight plastic composition that is easy to mold and cheap to produce. The cost of the foldable table ranges between $89.00 and $100.00 with a list price between $128.00 and $300.00. Their small size makes them easy to use with little disturbance to the general public, especially when used on public transportation. Their light weight is due to the lighter support materials used in their production. This small designed table is useful for anyone who is hospitalized for a brief period of time as well as for a handicapped person needing to operate a tablet or to read a magazine. However, as observed in Figure 2, there is hardly enough space for a laptop, textbooks, or papers; it is therefore not possible for a student to perform necessary tasks such as writing or studying. As one may observe in Figure 2, a chair with front wheels shifted to the side is preferable to a wheel chair like most with wheels in the front. This project aims to create a table that is heavy duty and adaptable for the everyday student.

2. Design Requirements

The entire structure must be tested with CATIA to ensure the parts do not exceed their maximum stresses. Adjustments are made to the design in order to minimize the cost without sacrificing the overall quality of the product. An analysis must also be performed on the wheel chair itself to ensure the added weight does not overwhelm the structure of the chair. Proper weight distribution of the product contributes to its functionality on any chair.

For the main table surface, the current goal is to have the table rotate around the top of its main support. This will place the table next to the tire and out of the way of the user. The table's support arm will then swivel at a predetermined point, allowing the table to be placed behind the chair and out of the way of the user. This swivel action serves two purposes. First, when the table is behind the chair it will allow the user full unrestricted access to the wheels and controls for the chair. Second, when the table is placed in front of the wheel, this position will allow the chair to be folded up and placed in the trunk of a vehicle for transportation. The table should be made thin enough so as not to add too much thickness to the chair in its folded position.

3. Engineering Requirements

For this table to work mechanically, there are many requirements that must not only be met, but also exceeded for the daily use of the chair.

1. It must have sufficient durability to survive both constant trips in a vehicle and daily use around the college campus.
2. The table must be compact and must swivel around to the back side of the chair.
3. It must be compatible with the folded position of the wheelchair to facilitate easy transportation.
4. The weight of the table should not exceed 15 pounds.
5. The cost of this design should be less than $300.

4. Modeling

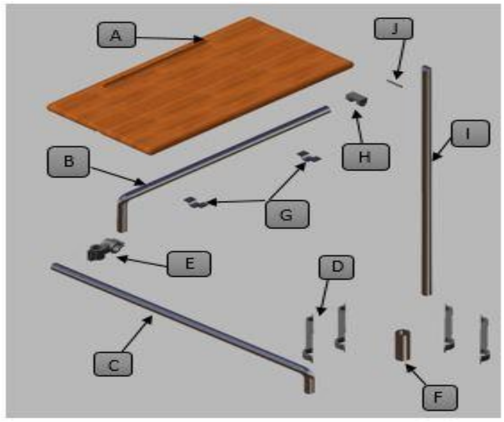

Figure 3: Table parts exploded view

The table will be created, assembled, and analyzed in CATIA V5 to ensure easy manipulation of parts and redesigns throughout the project. The design is comprised of the following pieces. All drafts are presented in millimeters. The above pieces all work together to make the design work as intended. The table (A) will be attached to the support arm (B) with the clamps (G). The table must rotate around this point to facilitate the folding process. The support arm will then rotate inside of the height adjuster (E) and fold alongside the main swing arm (C). The arm will rotate inside of a ball joint which will be mounted inside the swivel mount (F). Finally, the swivel mount will be attached to the frame of the wheel chair with four mounting brackets (D). The table appeared to need added support, so a leg was attached to the bottom side of the table which allows extra support when necessary (I and H). Finally, the table is locked in place with a spring assisted pin lock. Most of the structure was composed of a one inch thick pipe. This thickness was chosen because it matched the diameter of the wheelchair's main body. A thinner diameter contributes to a smaller overall space requirement for the table in its folded position. An assembled view of the table can be observed in Figure 4, while the folded table is observed in Figure 5.

Figure 4: This is the Current Design of the tabletop model for the wheelchair

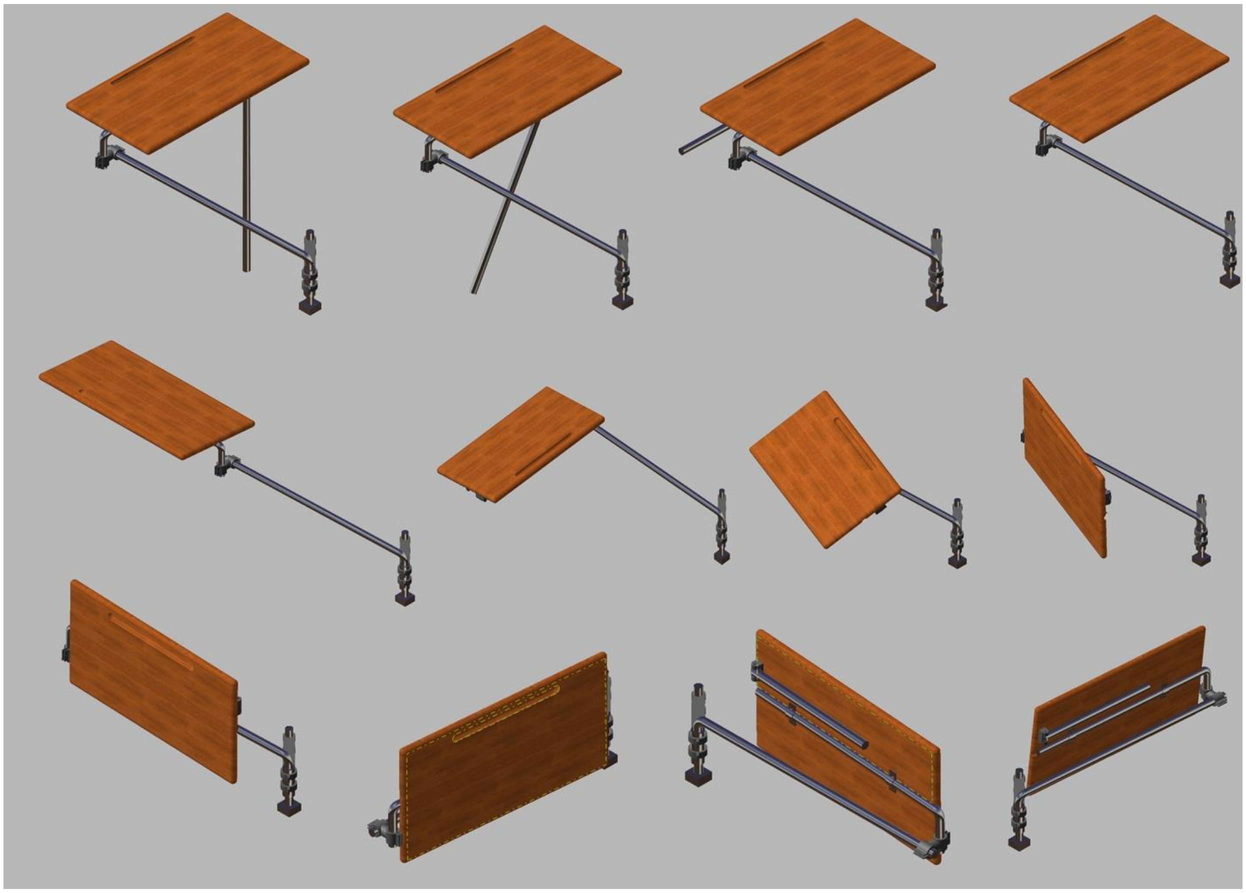

Figure 5: How the table folds: Step by Step

1. Table Fully open
2. Begin folding the leg
3. Leg folded completely
4. Collapse the leg
5. Begin rotating the main support arm (90o)
6. Continue rotating the main support arm (180o)
7. Begin folding the surface
8. Complete folding the surface
9. Finish rotating main support arm (270o)
10. Rotate swing arm (90o)
11. Continue to rotate swing arm (180o)
12. Finish rotating the swing arm (270o)

4.1 Materials Used

For the main body of the table, a solid piece of wood is used. Besides being a relatively easy material to work with, it is also very sturdy and holds up nicely with multiple uses. For the main support structure, solid 1-inch aluminum piping is used to give the long suctions the best chance at surviving under the required weight. For the height adjuster, mounting brackets, and leg support, a plastic material is used. For strength, PLA plastic is used on a 3-D printer. To create this part within safe specifications, we have chosen to use a factor of safety of 2. Because of the loads being applied to the table, we felt a factor of safety of 2 would be more than sufficient. Using the formula σ_{yp}/NFS, we are able to determine our allowable stress and begin testing.

Table 1: Material properties

	Young's Modulus (psi)	Poisson's Ratio	Density (lb/in^3)	Yield Stress (psi)
Aluminum 2224-T3	1.015e+007	0.346	0.098	43,100
Plastic	319082.898	0.38	0.043	6300
Pine Wood	2.466e+006	0.45	0.018	11300

5. Finite Element Analysis of the Table using CATIA

5.1 Mesh Selection

For the mesh, a tetrahedron mesh of 0.3 inches used for the analysis can be observed in Figure 6. This is the characteristic length of the tetrahedron. Because 0.3 inches is the best relative size, this measurement is a constant choice throughout the product. This allowed us to have more than enough detail while testing the parts while having the added benefit of cutting down on calculation time. This size was determined through a mesh convergence study.

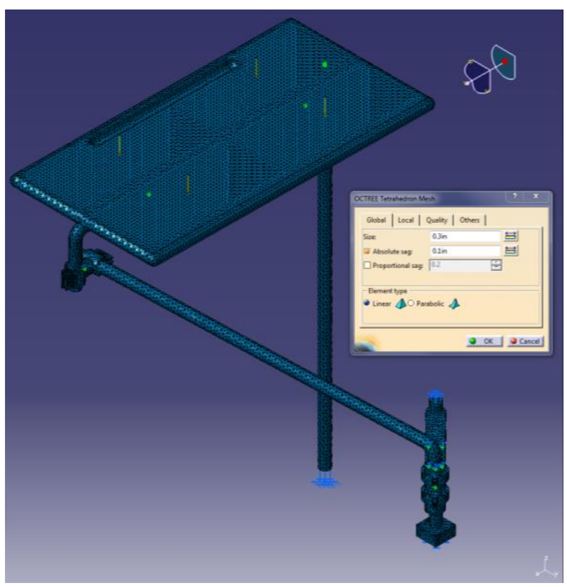

Figure 6: Tetrahedron Mesh of the Design

5.2 Loading and Boundary Conditions

A load of 50 lbs. was applied to the surface of the table in order to test its strength. The load was placed on the top of the table surface as a distributed load. Clamps were placed on the wheel chair's post that was created in order to connect all the pieces. This piece acts as a section of the wheel chair to which the rest of the fixture will be attached. The last clamp is placed on the bottom of the leg where the leg makes contact with the floor as pictured in Figure 7. A part was fixed together by first creating a general analysis connection and then assigning each of those connections as a face to face connection. This tells CATIA that the parts are connected during testing thus allowing the program to perform an analysis on the connection.

Figure 7: Loading and Boundary Conditions applied to the structure

5.3 Von Mises Stress and Deformation of the structure

The stress developed on CATIA is the Von Mises stress. This is based on the von Misses Henecky theory. The theory is demonstrated by this equation: $\sqrt{\sigma_1^2+\sigma_2^2+\sigma_3^2-\sigma_1\sigma_2-\sigma_2\sigma_3-\sigma_3\sigma_1} \le \frac{\sigma_{yp}}{NFS}$. For a safe design, the above criterion must be satisfied. After CATIA runs its built-in solver it will give us our maximum deformation as well as our maximum stress as shown in figure 8 for the entire structure. We can also probe high stress areas to see the exact stresses anywhere on the structure. The data are used to strengthen certain areas and reveal where we can possibly reduce material and the overall cost of the project. After testing the structure, we determined that there is a point of high stress in the model. The leg bolt is under shearing stress and the numbers indicate that the bolt

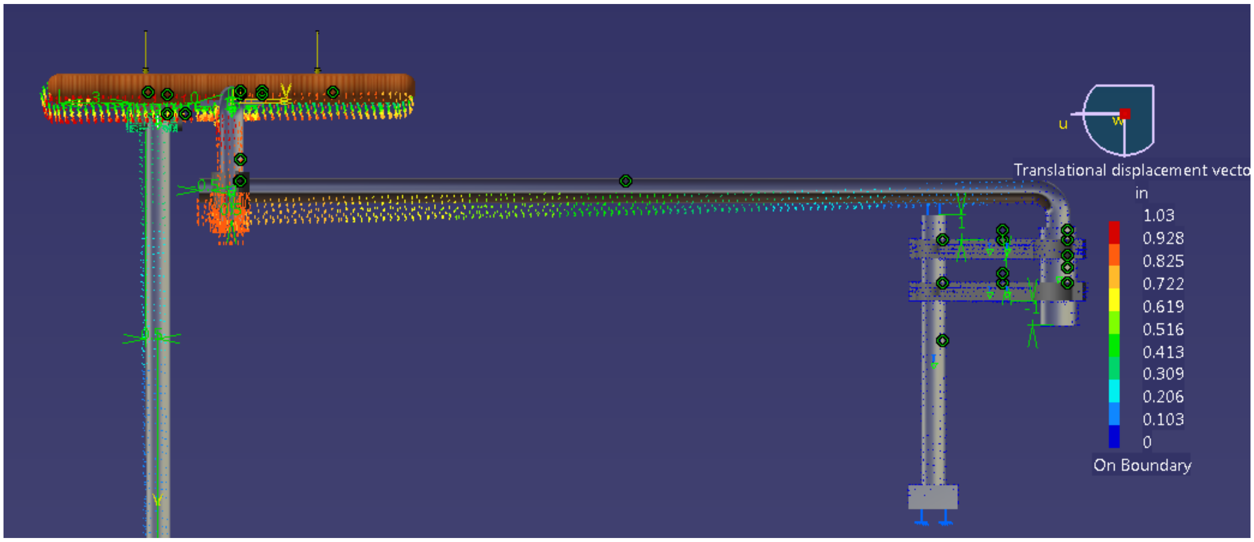

Figure 8: Displacement of the Table

will not meet our required allowable stress. A redesign of the bolt and the surrounding area should allow for better weight distribution. By increasing the diameter of the bolt, we should be able reduce the stress to a reasonable level. Just by increasing the size of the bolt, we were able to reduce the stress in the bolt by 63%. This also brings the bolt within safe loading for aluminum. The rest of the table is under its allowable stress. Lastly, the displacement of the table came out to be 1.03 inches. Although this seems like a lot of deflection, the arm is able to take the strain. Furthermore, this is supposed to be the table's maximum loading although adding another leg would improve the stability greatly.

6. Discussion of results

After the table was completed, we first looked at the displacement in the assembly. The structure deforms a maximum of 1.03 inches in the upper left corner. The structure deforms this way because the leg is only supporting the right side of the table. This is adequate for now because we are testing the table under its maximum load. We could greatly improve upon the displacement of the table by adding a second leg under the left side of the table. This, in theory, should decrease the maximum displacement to under a quarter of an inch. The leg could also be relocated to the center of the table, but this would most likely interfere with the user of the chair. Next, we took a look at the Von Mises Stress throughout the table. The stress in the table appears to be very low as observed in Figure 9, but this is because the structure is being compared to the area of high stress in the bolt located in the table's leg. As seen in Figure 10, the bolt is undergoing a shearing stress between the leg and the mounting bracket. Under the previous conditions, this bolt would have failed to meet the safety factor. The problem was solved by increasing the bolt's diameter and increasing the size of the leg and mounting bracket to compensate for the larger bolt. During the analysis of the part, possible sources of error were taken into consideration. One source of error is related to the element mesh size; an improvement in the results of both stress and deformation occurs with smaller and refiner element mesh sizes.

After execution of CATIA solver with smaller mesh size, the deformation had grown and the majority of the stress appeared in the support arm of the table. This test proves that the stress in the initial test was properly calculated.

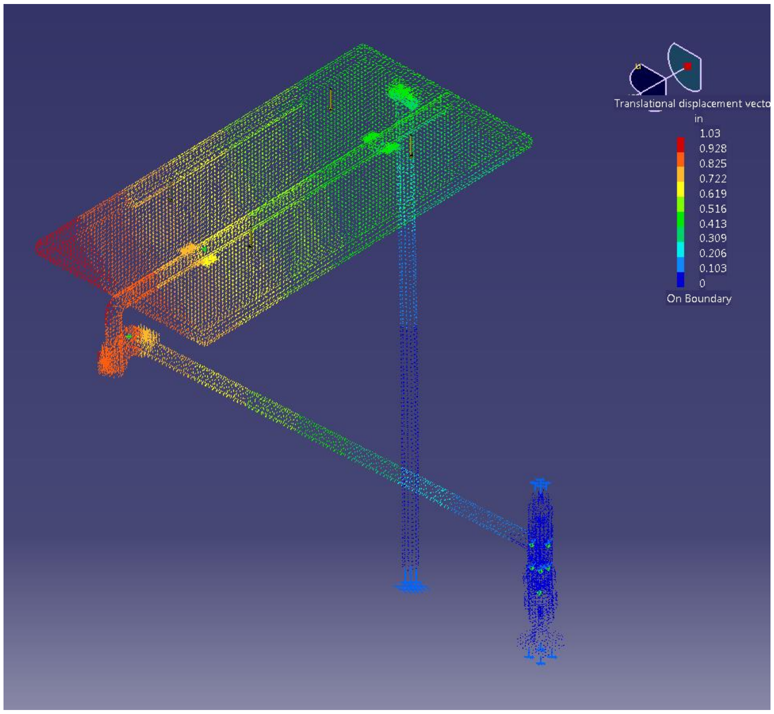

Figure 9: Deformation of the structure

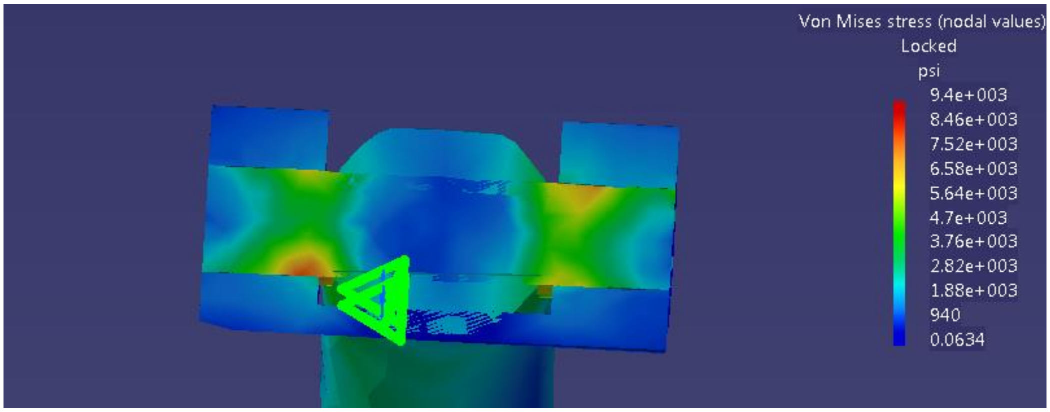

Figure 10: Stress in the joint

7. Conclusion

This project, dedicated to a group member's brother Brandon Dewitt, was designed in order to produce a table he could use at school and throughout his everyday life. This was an excellent project on which to apply Mechanical Engineering Technology Computer-Aided Design concentration knowledge. This project was mainly based on designing a model and assembling it in CATIA. During the project, all group members strengthened their knowledge of CATIA and learned a few new tips and tricks along the way, including how to join parts in CATIA and how to test an assembly. The project also incorporated knowledge acquired from material properties classes, from project management and from classes on stresses and loading types. Using all the information gained while at this institution, we were able to determine how to correctly edit the model in order to improve it in the future. The displacement is acceptable since this is the maximum weight for the table and adjustments can be made to counteract this condition.

Table 2: Results

	Original Bolt	New Bolt
Stress (ksi)	29.7	9.4
Diameter (Inches)	0.25	0.5
Displacement (Inches) (Front Right of Table)	1.3	1.03
$\sigma_V < \sigma_{YP}/N_{FS}$ (psi)	21,050 < 29,700	21,050 > 9,400

8. References

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Volumetric Flow Visualization System using CW Laser & Scanning Mirrors

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Abstract

In this project, a new and improved volumetric flow visualization system using continuous wave laser and scanning mirrors has been designed. This system is economical, has a uniform light intensity with the capability of producing multi-layer laser sheets to create a 3D image of the flow that is spread over a large volume. Compared to the existing devices used in the aviation and space technology industries, such as the Particle Image Velocimeter and the NFAC Long–Range Laser Velocimeter (LRLV), the light intensity of each sheet produced by the Volumetric Flow Visualization System is uniformly distributed and the strength of the intensity remains unchanged. This project was partially sponsored by Maxon Precision Motors, Inc., a leading company in building micro-motors used in humanoid robots, commercial aircrafts, camera lenses, race cars, cardiac pumps and other high precision industrial applications.

Keywords: Flow Visualization, Laser, Scanning Mirrors

1. Introduction

In the aviation and aerospace industry, work in the area of Fluid Flow Visualization is conducted in wind tunnels using various flow visualization systems which replicate the actual environment the object will face in the real world. The current best flow visualizer uses concave lenses to create a fan like projection of the laser to create a plain over the fluid flow which lacks in uniformity of the light intensity. These types of systems are used to visualize the fluid flow in 2-dimensions only. Therefore, the current best flow visualizer does not give an accurate result and can be improved through this design. This system design is not only economical but most importantly creates a volumetric picture of the flow around an object with uniform high intensity resolution which can immensely benefit the aerospace and aviation industry.

The objective of this project is to develop a user friendly, economical and effective volumetric airflow visualizer over 3-dimensional physical objects by utilizing optics and a high speed camera. The camera is used to capture the images of the flow, frame by frame, to create a 3D pictorial result. The concept used in this project is to utilize a single laser beam which is reflected from a set of mirrors placed on an octagonal disc. The disc is rotated at a high speed with the help of a motor and controller, which creates multiple laser planes parallel to each other with an increment of 5mm. These laser planes illuminate the smoke produced by a smoke machine. The camera is then used to capture the image of each plain which, when combined, gives us a volumetric visual of the smoke flow.

Various techniques of flow visualization are used in industries to study the flow through valves, pumps, flow meters, and other devices. It helps to optimize the design of the device based on flow factors such as the speed variations in different areas, flow separation, recirculation, and turbulent and laminar zones. Wind tunnels are used in most of the flow visualization methods to simulate the required environment around the object design [1]. Figure 1 shows flow visualization technique for the large wind tunnels of the National Full-Scale Aerodynamics Complex (NFAC) that uses a laser sheet produced by the NFAC Long-Range Laser Velocimeter (LRLV) to illuminate a smoke airflow.

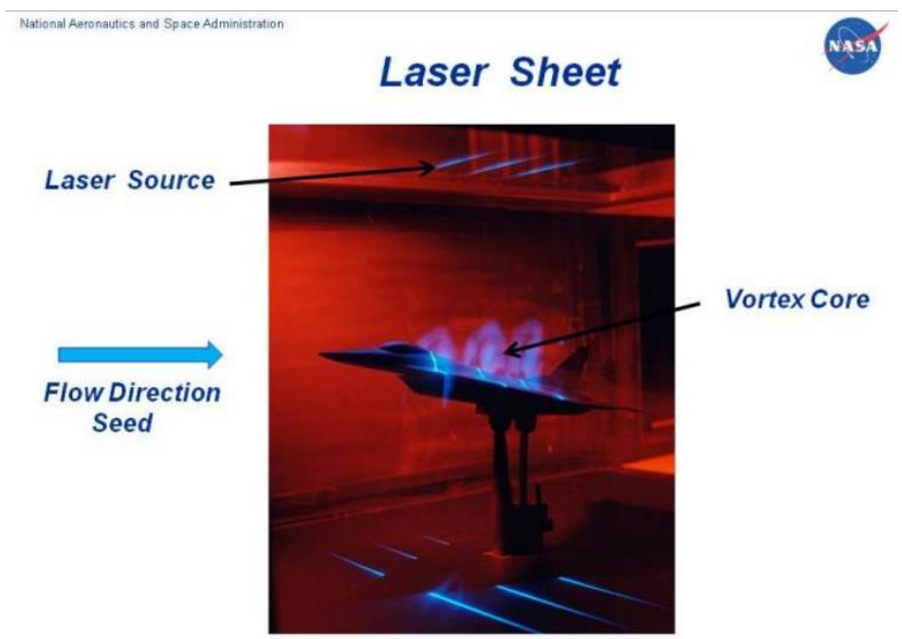


Figure 1: NASA Laser Sheet

As seen in the Particle Image Velocimeter (PIV) in Figure 2, the laser sheet is generated by using an incident laser beam and one or more cylinder-shaped optical lenses. These lenses cause the laser beam to spread out forming a fan shaped laser sheet which is then reflected onto the object in testing inside the wind tunnel, with the help of a mirror placed in a 45° angle. As the single laser beam energy is distributed over a larger area, the light intensity is also distributed non-uniformly. This results in a variation in the intensity of the laser sheet in Gaussian distribution. Therefore, the intensity is inversely proportional to the area of the laser sheet produced.

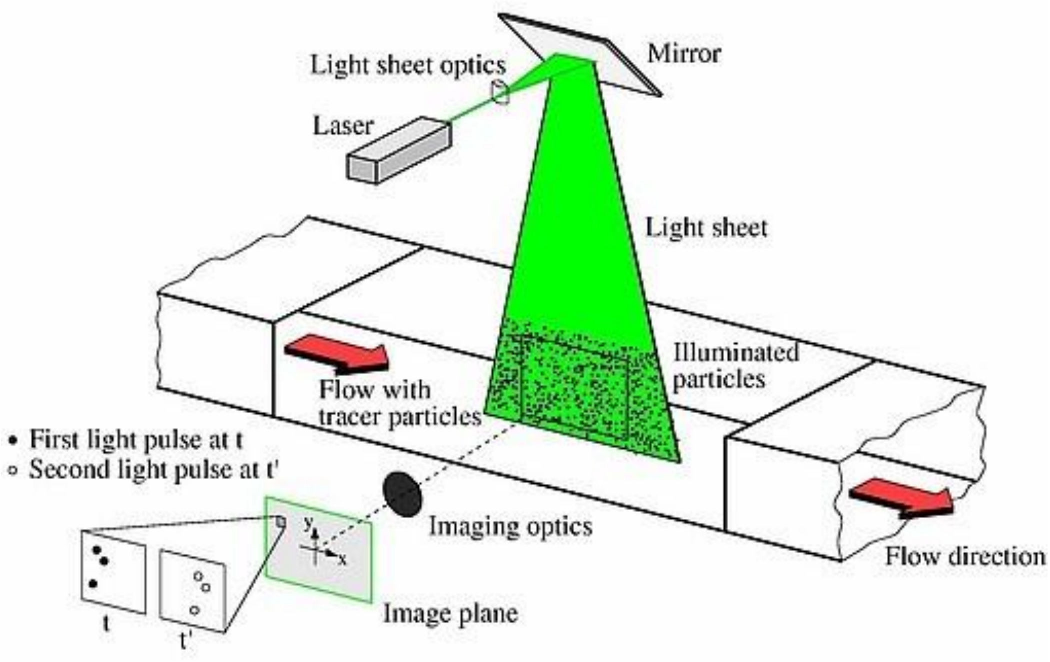


Figure 2: Particle Image Velocimetry

These techniques are modified using a new concept to overcome the drawbacks; i.e., the lenses in the system shown in Figure 2 are replaced by an octagonal disc mounted with mirrors which creates laser sheets with uniform intensity throughout the area of the sheet. The laser beam is not distributed across the sheet area. Therefore, the sheet has the same energy as the laser beam used. This project also focuses on creating a volumetric result instead of a 2-dimensional flow visualization system mentioned in the reference [2].

2. HARDWARE DESIGN

2.1. Frame Design

There were two options in constructing the frame design. One option was to design a skeleton-based frame on which to mount the disc. The other one was to have an enclosed Plexiglas frame where the disc is mounted on the inside of the frame. The decision was made to design the frame using the enclosed Plexiglas frame option in order to increase the safety component of the system. The enclosed frame option helps to avoid any injuries in the case of mirror detachment from the disc, due to centrifugal force while in the operation mode.

The design of the frame is based on the dimensions of the college wind tunnel opening 19” x 7”. Therefore, the frame dimensions were chosen to be 24” x 7.5” x 12”. After researching the material required to construct the frame, the decision was made to build the frame using the aluminum t-slot beams, which are light weight, strong and easy to assemble, as shown in Figure 3. Having completed the frame in which the final assembly of the project was to be mounted, there was an issue regarding the frame assembly, because incorrect screws were purchased. Correct screw size was required in order to attach the frame together with 90-degree angle brackets, as shown in Figure 4.

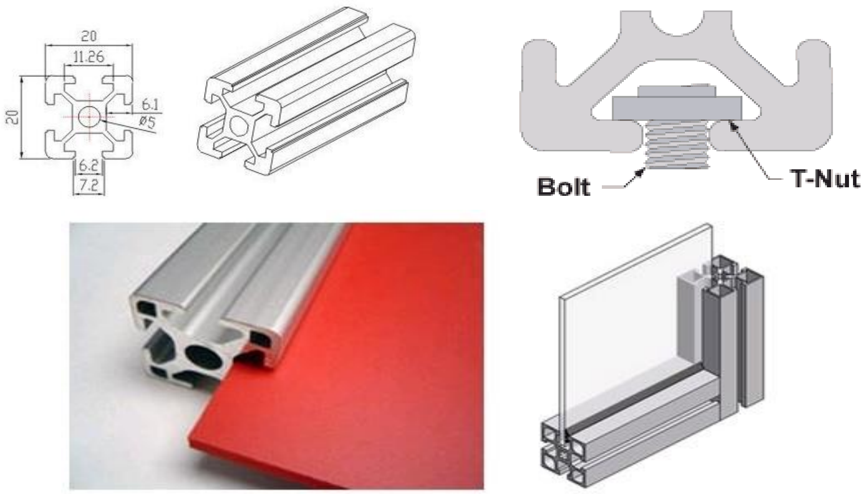


Figure 3: T-Slot Concept and Slotted Aluminum Extrusion

(A) (B)

Figure 4: Parts Needed to Install the Frame Together

To correct the error, new screws, 8mm in length, were ordered. The Plexiglas was cut according to the dimensions measured directly from the top of the wind tunnel as 12" x 12" x 24" (Figure 5A), and the motor was installed onto the frame by drilling into the Plexiglas along with the universal hub attachment. After everything was set up, it was determined that the laser reflection would not hit the center of the wind tunnel. Therefore, both the frame and the Plexiglas were re-cut according to the new dimensions of 7.5" x 12" x 24" (Figures 5B&5C).

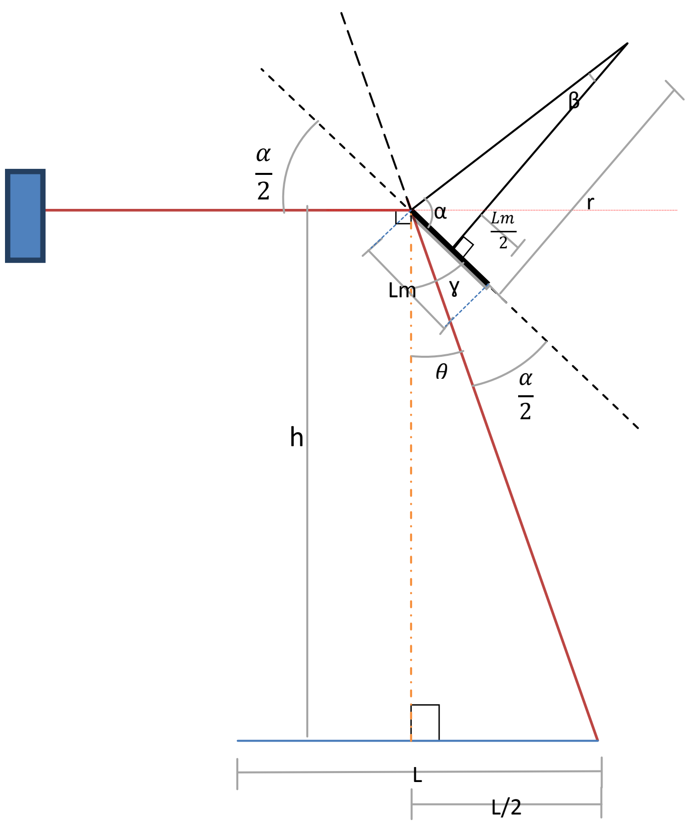
(A) Frame with size of $12\times12\times24 in^3$ (B)Frame Building in Progress (C) Motor and Controller Mounted

Figure 5: Development of the Frame

2.2. Disc with Mirrors

Calculation of Mirror Dimension

To find out the required dimensions for the mirrors, some calculations were conducted as shown below. The factors considered during the calculation were the radius of the disc, r, and the distance, h, between the bottom mirror and the base of the wind tunnel. Different lengths of the mirror, Lm, were considered to see how the length of the laser sheet, L, reacted, and the best fit mirror length was chosen.



Based on the tragicomic figure 6, the value of α can be found as follows:

$$\tan\alpha = \frac{r}{\frac{Lm}{2}} = \frac{2r}{Lm} \quad (1a)$$

$$\alpha = \tan^{-1}\left(\frac{2r}{Lm}\right) \quad (1b)$$

Furthermore, the relationship among β, θ, and γ in terms of α can be explained as follows:

$$\beta = 90 - \alpha \quad (2)$$

$$\gamma = 90 - \frac{\alpha}{2} \quad (3)$$

$$\theta = \gamma - \frac{\alpha}{2} \quad (4)$$

By putting (3) into (4) and (1b) into (5), we have:

$$\theta = 90 - \frac{\alpha}{2} - \frac{\alpha}{2} = 90 - \alpha \quad (5)$$

$$\theta = \beta$$

$$\theta = 90 - \tan^{-1}\left(\frac{2r}{Lm}\right) \quad (6)$$

Figure 6: Trigonometric Relationship between Angles

From Figure 6 we can also derive the following:

$$\frac{L}{2} = h\tan\theta \quad (7a)$$

$$L = 2h\tan\theta \quad (7b)$$

By putting (6) into (7b), we have:

$$L = 2h\tan\left(90 - \tan^{-1}\left(\frac{2r}{Lm}\right)\right) \quad (8)$$

Assume $h = 0.45m, r = 0.05m, Lm = 0.03m$, we can have $L = 0.27m$ by using Equation (8).

Design of Disc #1

One major factor to be considered in the design of the disc to hold the mirrors was to create parallel lines on the wind tunnel testing base by reflecting the laser beam from the mirrors while the disc rotated at a high speed. Many design approaches were discussed. The first idea was to make a cone shaped spiral disc. However, this particular idea was dismissed due to the difficulty of accurately placing the mirrors on the disc. The second idea was to design a cylindrical disc with mirrors attached to it in a spiral at a 45° angle. Another decision was made to incorporate eight mirrors surrounding the disc. Since each mirror uniformly takes an angle of 45° of the round disc, this would facilitate both the design and implementation and calculation of the required torque value for the rotating motor. Furthermore, errors would be much more easily identified.

The first disc prototype was designed in an octagonal shape and the disc dimensions were measured in mm as shown in Figure 7. However, the design had a problem. The mirror attachment area was too small and impractical. Therefore, it was used for primary testing only to see whether the parallel plane theory works by attaching the mirrors with dimensions of $1 \times 1\ cm^2$. This experiment was successful and assisted in the implementation of the second design of the disc.

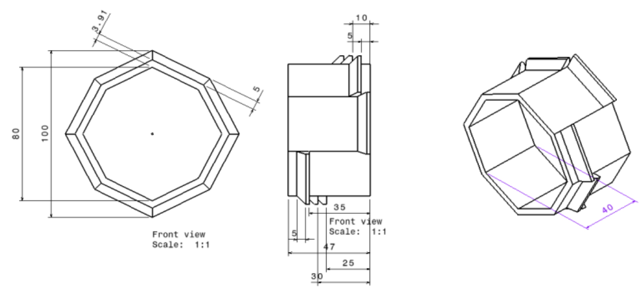


Figure 7: CATIA Part Design for Disc #1 (mm)

Design of Disc#2

In this design, the mirror attachment area was increased to facilitate the appropriate size of the mirrors. For safety reasons, the decision was made to implement grooves into the disc to prevent the mirrors from breaking loose due to the generated centrifugal force during the high-speed rotation of the motor. This procedure resulted in an increase in the distance between the mirrors which increased the distance between each parallel laser sheet. To keep the distance between mirrors as per the engineering requirement, it was decided to replace the grooves with mirrors screwed onto the disc. Three screws per mirror were diagonally placed to hold it in place (Figure 8). Once the disc was printed using a 3D printer, it was found that the part was too bulky for the motor [3] and it was nearly impossible to make holes in the mirrors without cracking them or drilling the holes in an accurate place without the drill bit slipping to an incorrect spot.

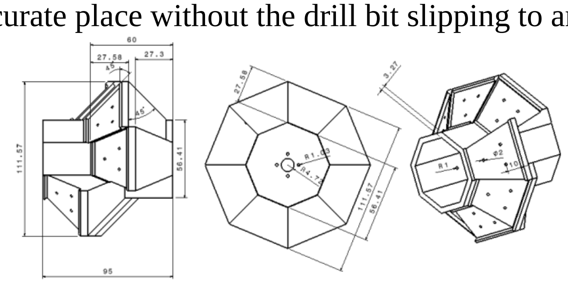


Figure 8: CATIA Part Design for Disc #2 (mm)

Design of Disc#3

The final design of the disc was a smaller size (See Figure 9) to that of previous designs. The mirrors were secured using a strong adhesive material, i.e. gorilla glue. As safety was an important factor, it was decided to design an enclosed Plexiglas frame to hold the disc inside of the frame in order to increase the safety of the system. Several experiments were conducted with various rotational speeds of the motor to test the strength of the glue. The testing results were satisfactory.

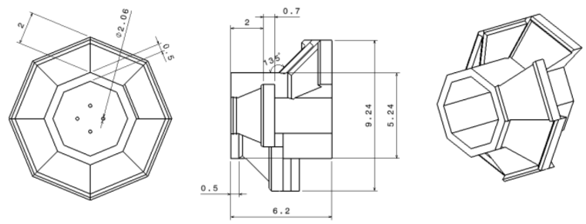


Figure 9: CATIA Part Design for Disc #3 (mm)

Centrifugal Force Calculation

The centrifugal force on the mirrors was calculated to ensure that none of the mirrors detach whenever the disc is rotated at a high speed. The centrifugal force was calculated in the following process.

The angular to linear velocity formula is

$$v_t = r \times \omega, \qquad (9a)$$

where
v_t = Linear velocity in m/s
r = Radius in meter
ω = Angular velocity in rad/s.

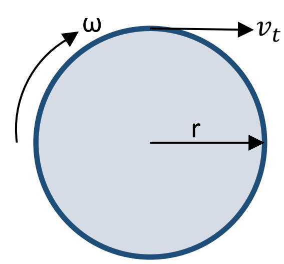


Figure 10: Linear Velocity

The revolution per minute (RPM) to Equation (9a) is

$$v_t = r \times RPM \times \frac{2\pi}{60} \qquad (9b)$$

Equation (9b) was used to calculate for r = 0.05m and ω = 6110 RMP (maximum speed produced by the motor).

$$v_t = 0.05m \times 6110RPM \times \frac{2\pi}{60}$$

$$v_t = 31.99196\ {}^{m}/_{s}$$

For the centrifugal force, we have the following equation [7],

$$f = m\frac{v^2}{r} \qquad (10)$$

where,
$m_{glass} = \rho \text{LH}\frac{A+B}{2}$ and ρ = the density of glass,
L, H, A, and B can be seen in Figure 11.

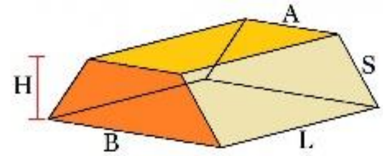


Figure 11: Trapezoid

By the given L = 0.00254, H = 0.025m, $\frac{A+B}{2} = 0.03m$, and ρ_{glass} = 2500kg/m^3, the mass of the glass mirror can be calculated as follows,

$$m_{glass} = \frac{2500kg}{m^3} \times 0.00254m \times 0.025m \times 0.03m = 0.00476kg$$

Put the value of m_{glass} obtained from (11) into (10); we have the following result,

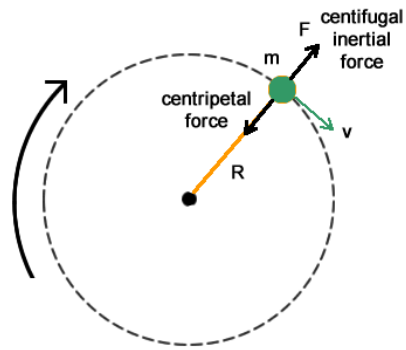


Figure 12: Centrifugal Force

$$f = (0.00476kg)\frac{(31.99196m/s)^2}{0.05m} = 97.436 \text{ N} \approx 21.9 \text{ lbf}$$

For the required disc radius and motor RMP value, r = 0.05m and ω = 400 RMP, the motor linear velocity and centrifugal force are,

$$v_t = 0.05m \times 400RPM \times \frac{2\pi}{60} = 2.0944\ {}^{m}/_{s}$$

$$f = m\frac{v^2}{r} = .00476kg\frac{(2.0944m/s)^2}{.05m} = .417 \text{ N} \approx 0.09 \text{ lbf}$$

Motor Selection

Several factors to be addressed before the motor was chosen are as follows:

(1) Brush vs. Brushless

Brush-type motors are generally used below 5,000 RPM. The factors that limit brush motor life include commutator bar-to-bar voltage and brush current density. Additionally, power at the brush-commutator interface can produce excessive arcing which erodes brushes once erosion begins. Brushless DC motors, on the other hand, have no brushes so there is no arcing to reduce the life of the motor. Brushless DC motors are also better suited for applications needing a wide speed range. A DC brushless motor, suitable for different speeds for testing and future use, was selected for this application.

(2) Size of Motor

Size of the motor was a necessary requirement for this application. Bulk motors could possibly topple over the frame due to their weight. Therefore, a lightweight motor was considered rather than a bulky motor in order to lessen the possibility of damage to the motor occurring during moving, testing or storing the system.

(3) Speed of Motor

Speed was one of the most important requirements for this project because a rotational motor speed of at-least 450 RPM was required. The minimum speed required was needed in order to spin the disc to obtain a continuous laser sheet on the base floor of the wind tunnel.

(4) Torque Requirement

The torque required for this application was approximately 0.009 Nm.

(5) Controllability of Motor

The speed feedback signal was required by this application in order to observe the speed of the motor as the input of the speed was changed. Brushless DC motor controllers require a position feedback signal from a sensor inside the motor which can be used to obtain the actual speed of the motor.

The EC Flat 45 motor (See Figure 13) by Maxon Precision Motors was selected to satisfy the above mentioned parameters required for the motor. The specification of the motor with the cable specifications is referenced in [4][5]. This particular motor is brushless so that there will be no arcing in the motor during high speeds thus increasing the life of the motor. The size of the motor is compact so that it can fit even in tight spots, but most importantly, it is a lightweight motor. The speed requirement for the motor is satisfied, as this motor has the capability of producing speed above 6,000 RPM. The EC Flat 45 is capable of producing the torque of 128m Nm, which is above the torque requirement for this application. Lastly, the speed signal can be required via the use of the controller in conjunction with the motor.

Figure 13: Selected MAXOM Motor

Calculating Torques for the Rotating Motor

Torque calculation of the rotating motor was a critical step for the design process, which was directly related to the selection of the motor to drive the disc. We derived the torque value using the calculated inertia, I, multiplied the angular acceleration, α. [6][7][8]

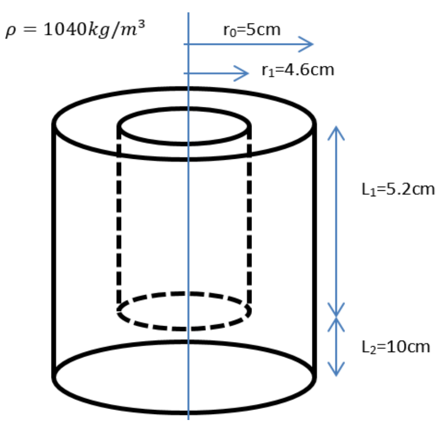


Figure 14: Torque

As shown in Figure 14, we consider the radius, the volume and mass of the disc as r, V, m, respectively, and the area of the top ring is A ($A = \pi r^2$). Then we have

$$dI = r^2 dm \quad (12)$$

$$dm = \rho dV \quad (13)$$

$$dV = LdA \quad (14)$$

$$dA = 2\pi r dr \quad (15)$$

By putting (15) into (14), we have:

$$dV = 2\pi rLdr \quad (16)$$

By putting (16) into (13), we have:

$$dm = 2\rho\pi rLdr \quad (17)$$

By putting (17) into (12), we have:

$$dI = 2r^3\rho\pi L dr$$

$$I = 2\rho\pi L \int_{r_i}^{r_o} r^3 dr = 2\rho\pi L(\tfrac{r_o}{4} - \tfrac{r_i}{4}) \quad (18)$$

$$\rho = \frac{m}{\pi(r_o^2 - r_i^2)L} \quad (19)$$

By putting (19) into (18), we have:

$$I = \tfrac{1}{2}m(r_o^2 + r_i^2) \quad (20)$$

$$I = \tfrac{1}{2}mr^2 \quad (21)$$

When the disc has both inner and outer radius, the moment of inertia can be obtained using Equation (20). However, if the disc only has an outer radius, Equation (21) can be utilized to calculate the moment of inertia.

$$I = \sum m_i r_i^2 = m_1 r_1^2 + m_2 r_2^2 + \cdots \quad (22a)$$

$$I = \tfrac{1}{2}m(r_o^2 + r_i^2) + \tfrac{1}{2}m{r_o}^2 \quad (22b)$$

The mass equation below is derived from Equation (19),

$$m = \rho\pi L(r_o^2 - r_i^2) \quad (23)$$

By putting (23) into (22b), we have:

$$I = \tfrac{1}{2}\rho\pi L_1(r_o^2 - r_i^2)(r_o^2 + r_i^2) + \tfrac{1}{2}\rho\pi L_2 r_0^2 {r_0}^2 \quad (24)$$

By plugging in the value of ABS plastic, ρ = 1040 kg/m^3 and other values we have into Equation (24), we get:

$$I = 0.5\pi\left(\frac{1040kg}{m^3}\right)(0.052m)(0.05^2m^2 - 0.046^2m^2)(0.05^2m^2 + 0.046^2m^2) + 0.5\pi\left(\frac{1040kg}{m^3}\right)(0.01m)(0.05^4m^4)$$

$$I = 2.52677x10^{-4}\ Kg \cdot m^2$$

Consider the torque as T, the testing air flow *v* is 10m/s, the distance from laser beam to testing area *h* ≈ 0.25m; then the angular acceleration, α, and the angular velocity, ω, can be obtained from the following expressions:

$$\omega = \frac{v}{h} = \frac{10\frac{m}{s}}{0.25m} = 40\,\frac{rad}{s} \approx 400rpm$$

$$\alpha = \frac{d\omega}{dt} \approx \frac{\Delta\omega}{\Delta t} = \frac{40\frac{rad}{s}}{5s} = 8\,\frac{rad}{s^2};$$

$$T = I\alpha = 2.52677 \times 10^{-4}(Kg\ m^2) * 8\left(\frac{rad}{s^2}\right) = 0.0020214\ Nm$$

where Δt = 5s.

Controller

The ESCON 36/3 type controller was utilized for this application. It is a small-sized, powerful 4-quadrant PWM servo controller for the highly efficient control of permanent magnet-activated brushless EC motors up to approximately 97 watts. The controller hardware features include speed control open or closed loop, current control, speed ramp, analog set value, digital I/O, configurable potentiometers, and I×R compensation factor for users to operate according to their needs. This controller is designed to be configured via USB interface using the graphical user interface ESCON Studio for Windows PCs. This particular controller also has status indicators to notify the user of any potential problems which include the green LED, meaning that the controller is operational and red LED, meaning that the controller has an error. For the application in the project, the controller's digital I/O's mode was utilized to obtain the desired output from the controller. The controller uses 12V input source to produce different functionalities via analog or digital I/O's. For the application, the motor was to operate at a constant speed of at-least 400 RPM, which can easily be accomplished either by setting the value or by adjusting the desired value using the ESCON studio software.

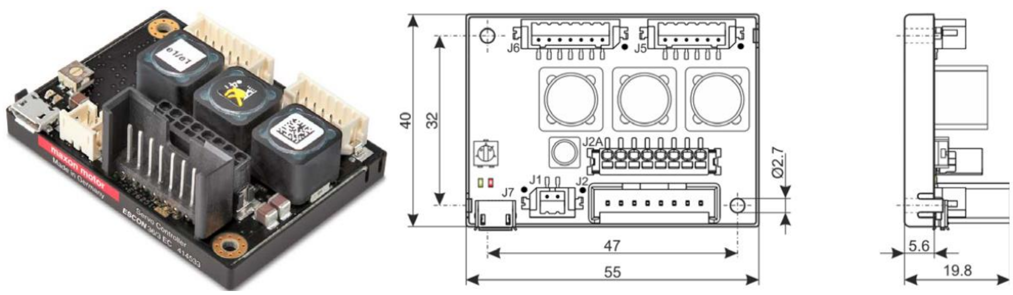


Figure 15: Controller

Once the controller is supplied with 12V of DC source then the controller driver needs to be activated to run the motor. The ESCON 36/3 controller has four digital I/O ports that the user can implement. The digital I/O #2 was used to run the motor and the digital I/O needs to be activated with the use of 5V obtained from the controller itself. Once the digital I/O is supplied with 5V supply then the controller drive is activated, and the motor starts to produce the uploaded speed set via the startup wizard in the ESCON studio software [9].

3. SOFTWARE DESIGN

Studio Software

The software utilized by the MAXON Precision Motors is called the ESCON Studio which is a user-friendly servo controller program. This particular software has a wide range of functionalities with digital and analog inputs and outputs. The software provides the user with speed control, current control, commands by a set value, maximum efficiency, open or closed loop, and circuit protection. The ESCON Studio software is required to operate the controller and the motor. In order to produce a desired outcome in the operation and the control of the motor, users must be familiar with the operation of the software.

The primary objective of our project was to run the motor at 500 RPM so that the mirrored disc could produce a straight line sheet. In order to accomplish this task it is necessary to understand the functions pertaining to the Digital I/O's and to the speed control of the motor. This objective was accomplished by using a set value option to control the speed of the motor via the ESCON Studio. The software can be utilized in two different ways in order to obtain the required speed of the motor. One way is to go through the startup wizard to set all of the parameters required for the controller to operate the motor. These parameters can be uploaded to the controller via the

ESCON studio software. Once the file is uploaded to the controller, the motor connected to the controller can be used with the supplied input voltage of 12Volts. The other way to employ the software is to establish communication between the motor, the controller and the ESCON studio software to set the parameters and manually operate different tools in order to adjust the speed of the motor and to observe the actual speed reading from the Hall sensors[4][9].

Phantom Camera Control (PCC)

The main software application for Phantom camera users is the Phantom Camera Control (PCC). Although many of the newer Phantom models have On-Camera control the V311 model that was used for this project did not. PCC is the only place that controls every camera function on every Phantom camera model. To control and fine-tune the cameras resolution, frame rate, exposure, memory segmentation, trigger modes, and automatic functions prior to recording, the PCC was used. Also, the PCC makes it easier to convert files to the format needed for the project.
The PCC's menu tool for images includes a histogram to monitor exposure and other controls to adjust both advanced and basic image parameters. Since Phantom Cine files are raw, the parameters are applied as metadata and only incorporated when the file is converted to a different format. Cine files can be edited and saved individually or by batch-functions. PCC has the ability to perform basic measurements for motion analysis such as analyzing distance, angle, velocity, and angular velocity [10][11].

ImageJ Program

ImageJ is a Java-based image processing program and can be used to solve many image processing and analysis problems, from three-dimensional live-cell imaging to radiological image processing. ImageJ can display, edit, analyze, process, save and print 8-bit color and grayscale, 16-bit integer, and 32-bit floating point images. We used ImageJ to stack images together so that a single image displays the result of multiple images. This procedure was implemented in experiments 6 and 7 in order to determine the distance between each line that was created [12].

4. CONCLUSION

An innovative volumetric flow visualization system was developed in this project. As we know, flow visualization is important to the aviation and aerospace industry. It allows engineers to better understand flow patterns over an object and to thus optimize the object's design. In our project we designed the round disc which houses eight mirrors uniformly with 45 degrees per mirror and a 5 mm different level in depth between each mirror. The disc is mounted on a high-precision EC motor. When a laser beam hits mirrors rotated at a high speed, the flow in a wind tunnel is clearly visualized.

In comparison with previous flow visualization designs, this design is cost efficient and produces multilayer laser sheets with uniform distribution of light intensity. The project provides industries with the opportunity to better understand fluid mechanics with visual aids. Rather than calculating thousands of points in a supercomputer, while making a number of assumptions, the 3D flow visualization system can be used to obtain actual flow information. This device can also be used in educational institutions in order to help students visualize and understand fluid flow behaviors.

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H-Bar Design for Two Side Facing Seats in a Helicopter

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ABSTRACT

The purpose of this project was to focus on designing H-Bar to support two side-facing seats in a UH-60M. These seats will be installed behind the cockpit where two crew members can sit, and the design is also required to facilitate an inter-communication system for the crew who sit on these seats. The main concentration of this project is to design the h-bar according to specific dimensions which are applicable in an aircraft.

This h-bar is designed only for specific helicopters since each aircraft has a distinct internal airframe structure. The H-Bar design was modeled in CATIA V5. There were four individual parts designed in CATIA Workbench. Then, H-Bar parts were assembled into assembly workbench. Before structural analysis, material had been applied in assembly. In addition, Aluminum Alloy (7075-T73510) material was used to fabricate the H-Bar. This aluminum alloy is widely used in the aerospace industry due to its robust strength properties. 7075 is an aluminum alloy with zinc as the primary alloying element. It is strong, with strength comparable to many steels, and has good fatigue strength and average machinability, but it has less resistance to corrosion than many other Al alloys. Due to its high strength, low density, light weight, low cost, thermal properties, and its ability to be highly polished, 7075 is widely used in the aerospace industry.

Subsequently, the h-bar assembly with specific material was imported into structural and analysis workbench to apply F.E.A (Finite Element Analysis). The FEA was conducted based on the worst scenario loading condition. These loading conditions were predetermined by the aircraft manufacturer in terms of G-force. The G-force is then converted into forces applied for our H-bar configuration. These loads also accounted for the margin of safety required by the manufacturer.

1. INTRODUCTION

The determination of this project is to design the H-Bar for the specific Helicopter. The reason to choose this design is to build a structure to support two side-facing seats which are hung with seat-shock clevis chrome on the lateral side of the H-Bar and usually installed behind the cockpit. The H-Bar structure is also required to be light weight while sustaining all the loading conditions according to the military standard in an aircraft. Three-dimensional loading conditions were applied on each point, both lateral side, where both seats were hung. The magnitude of the forces was taken from twelve different cases, according to G values. Each scenario has correspondent three dimensional forces which apply on an aircraft accordingly. In the H-Bar case, we applied “Case 8” which is combined load for both side-facing seats. In Figure 1, free body diagram describes three dimensional forces at different direction. Those forces are denoted by P1 through P12. Due to the industrial nature of this project, the actual applied forces at a specific location in both side-facing seats cannot be disclosed. However, aeronautical design, in general, requires material to be light, and aluminum alloy material is thus more suitable for this structure. In industry, aircraft seats are designed and manufactured by Martin Bakers Co. This company is renowned for producing eject seats in aircrafts according to military standard MIL-STD. Once the design is furnished in CATIA V5, the model is imported into finite element workbench to calculate the displacement, deformation, maximum and principal stress in H-Bar due to 3 dimensions applied load at the specific location of the bar.

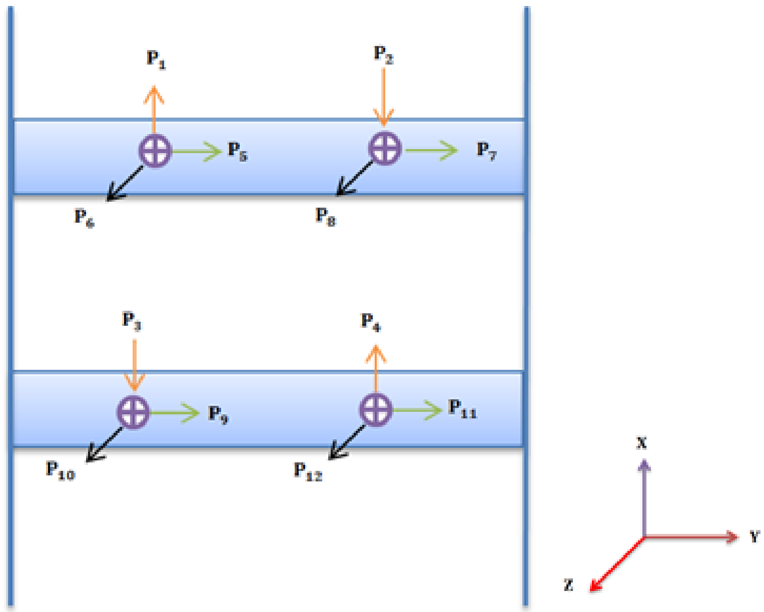

Figure 1: Free body diagram of 3-D applied forces in H-Bar

2. Objective

The objective of this project is to implement new h-bar design for side-facing seats which are installed behind the cockpit of an aircraft. The new h-bar design is used in industry for holding two side-facing seats with an occupant weight of two crew members. One crew member sits on the Starboard seat (Left Side) and the other sits on the Port seat (Right Side), on both sides, against the window. The whole structure of h-bar was designed in CATIA V5. Mathematical equations were used to numerically and analytically calculate the structural analysis of this bar in order to cognize the entire structure under the margin of safety.

3. Design

To understand the structural analysis process, h-bar project is divided into the following four parts.

- H-Bar Design in CATIA V5
- Finite Element Analysis (Numerical Method) in CATIA V5
- Analytical Method using mathematical equations
- Shear & Moment Body Diagram of H- Bar

3.1 H-Bar Design in CATIA V5

H-Bar design is based on four parts: the hollow longitudinal tube, hollow lateral tube, ICS (Inter-communication System) fitting grip, and Clamp & Pin. These parts were designed in Part Design, CATIA V5 Workbench. These parts were designed according to specific dimensions; all parts were imported in assembly workbench to produce the right shape shown in Figure 2.

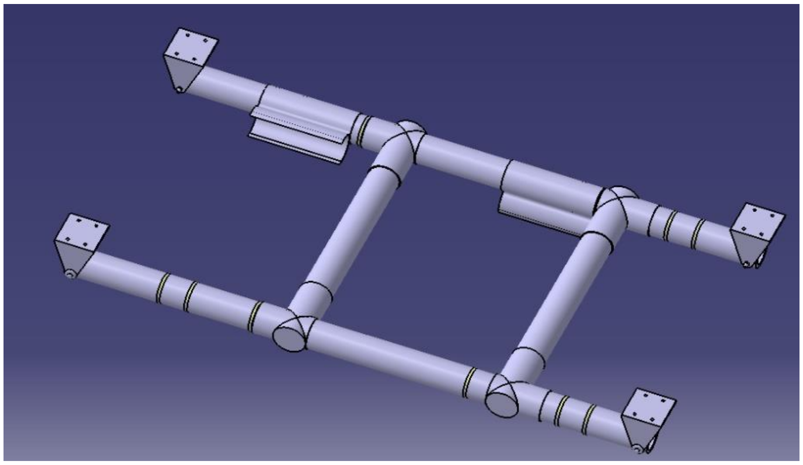

Figure 2: Completed H-Bar assembly in CATIA V5

Next, material Aluminum Alloy (7075-T73510) was applied on H-Bar structure prior to conducting finite element analysis using CATIA FEA workbench.

3.2 Finite Element Analysis (Numerical Method) in CATIA V5

The whole assembly of H-bar was imported in "Analysis & Simulation" Workbench where the "Generative Structural Analysis" option was used to perform Finite Element Analysis. Initially, smaller mesh size option was applied on all parts of the h-bar which is under "Nodes and Element" tree. Then, all mesh sizes were computed for visualization on h-bar as shown in Figure 3.

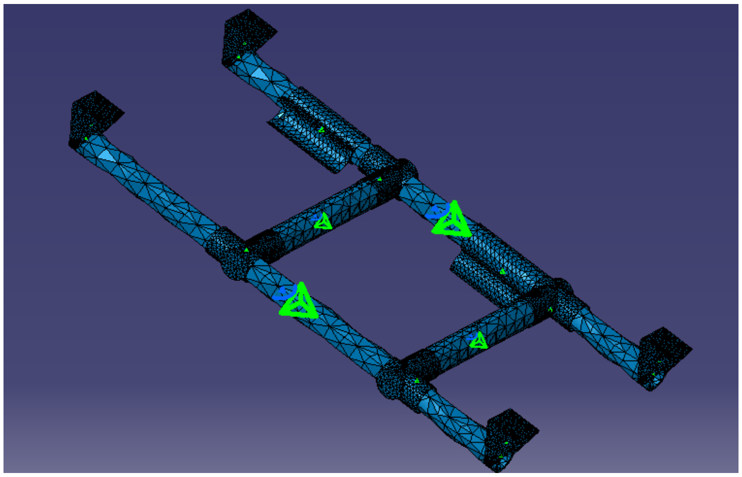

Figure 3: Smaller Mesh Size Visualization on H-Bar, CATIA V5

Next, General Analysis Connection tool was used to apply contact surfaces on each section of the h-bar. This was the most critical part in F.E.A. If one contact surface is missing in the design, the software will produce an error. A lot of time was necessary for careful consideration of contact surface of each portion in h-bar parts. A total of 44 contact surfaces were analyzed using FEA structural analysis workbench. Then, boundary conditions were applied on h-bar by using CATIA restrain tool bar. Four restraints were used on the upper surface of the clamps as shown in figure 4. Three dimensional loading conditions were then applied on the lateral tube of the h-bar by choosing loading tool in CATIA V5. The load were exactly applied on both sides of the lateral tube where both the side-facing seats are to be hung along with occupant weights. These loading conditions are MIL-STD which is commonly used depending on the different aircraft model. All values are then computed to get the final result which includes Von Mises, maximum stress, and displacement & principal stress, as shown in Figures 5 & 6.

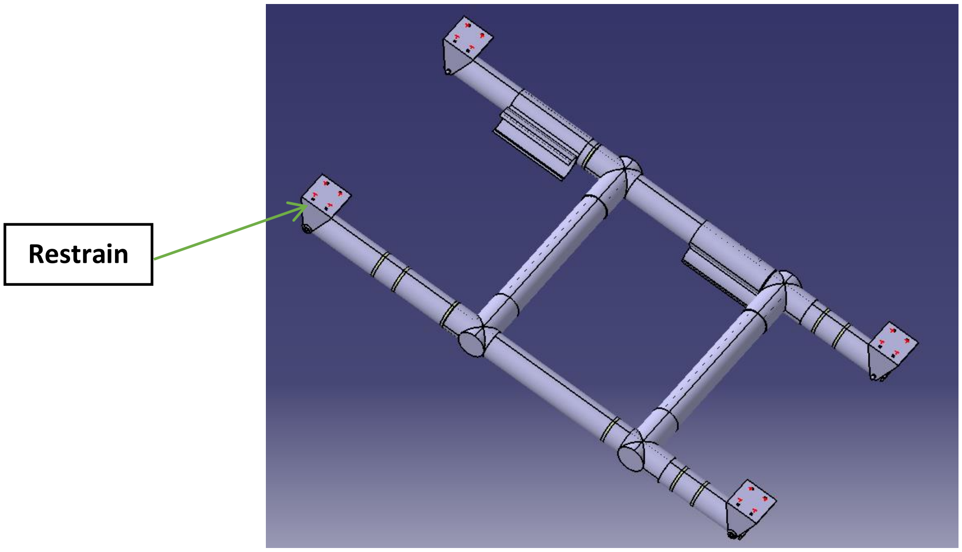

Figure 4: Four boundary condition restraints on the upper surface of the clamps in H-Bar

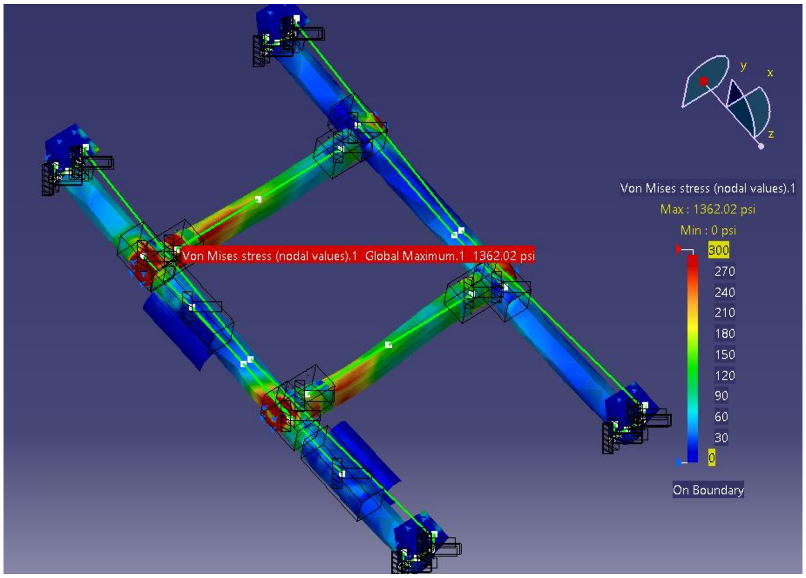

Figure 5: Von Mises Global Maximum Stress 1362.02 psi

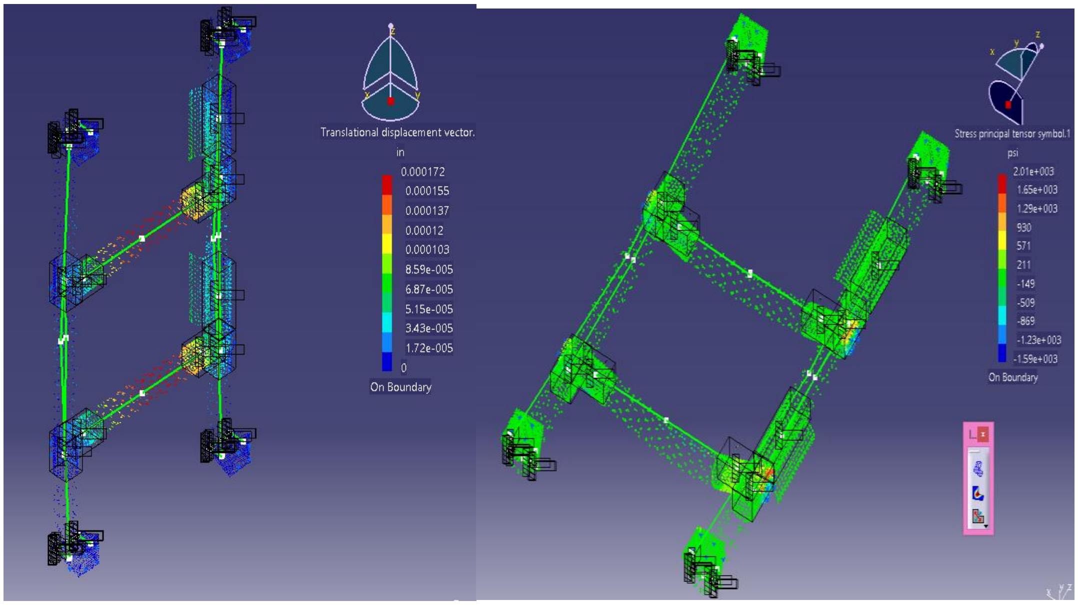

Figure 6: The translational displacement vector (Left) & Principal Stress (Right) in H-Bar. The colors indicate the magnitude of the displacement.

4. **Analytical Method using mathematical equations**
   Numerical method of H-Bar was performed in CATIA V5. Mathematical equations were used to find analytical values of the whole structure which are broken down into a few steps.

H-BAR MATHEMATICAL SECTION

These are the basic formulas which were used to perform analytical structure analysis of H-Bar

FIRST MOMENT OF INERTIA OF LONGITUDINAL TUBE GEOMETRY

$$Q = \left(\pi * \frac{OD^2}{2} * \frac{4 * \frac{OD}{2}}{3 * \pi}\right) * \left(\pi * \left(\frac{OD}{2} - t\right)^2 * \frac{4 * \left(\frac{OD}{2} - t\right)}{3 * \pi}\right)$$

$$Q = \left(\pi * \frac{2^2}{2} * \frac{4 * \frac{2}{2}}{3 * \pi}\right) * \left(\pi * \left(\frac{2}{2} - 0.25\right)^2 * \frac{4 * \left(\frac{2}{2} - 0.25\right)}{3 * \pi}\right) = 0.77083 \text{ in}^4$$

MOMENT OF INERTIA

$$I = \frac{\pi}{4} * \left(\frac{OD}{2}\right)^4 - \frac{\pi}{4} * \left(\frac{ID}{2}\right)^4$$

$$I = \frac{\pi}{4} * \left(\frac{2}{2}\right)^4 - \frac{\pi}{4} * \left(\frac{2 - 2 * 0.25}{2}\right)^4 = 0.53689 \text{ in}^4$$

AREA

$\mathbf{A} = (\pi * r^2 od) - (\pi * r^2 id) = (\pi * 1^2) - (\pi * (1 - 0.25)^2) = 1.374\ in^2$

POLAR MOMENT OF INERTIA FOR HOLLOW TUBE IN H-BAR

$$J_O = \frac{1}{2} * \pi * \left(\frac{OD^4}{2} - \left(\frac{OD}{2} - t\right)^4\right) = \frac{1}{2} * \pi * \left(\frac{2^\wedge 4}{2} - \left(\frac{2}{2} - 0.25\right)^4\right) = 1.07379\ in^4$$

TOTAL STRESS DUE TO BENDING IN H-BAR

$$\sigma = \frac{M * C}{I}$$

M=Moment, C= Distance from Centroid, I= Moment of Inertia

TORQUE

$$\tau = \frac{V * Q}{I * t}$$

V= Shear Force, Q = is the first moment of the area between the location where the shear stress is being calculated and the location where the shear stress is zero about the neutral (centroid) axis, and t= is the thickness of the cross-section at the location where the shear stress is being calculated.

MARGIN OF SAFETY

$$M.S = \frac{\sigma_{allowable}}{\sigma_{max}} - 1$$

Analytical Method Approach:

First, construct the free body diagram to find maximum shear and moment in the forward direction of the h-bar as shown in Figure 7. To calculate the shear and moment in the bar, it is very important to find the reaction forces which should be in equilibrium with the concentrated load on the bar (P1 & P2).

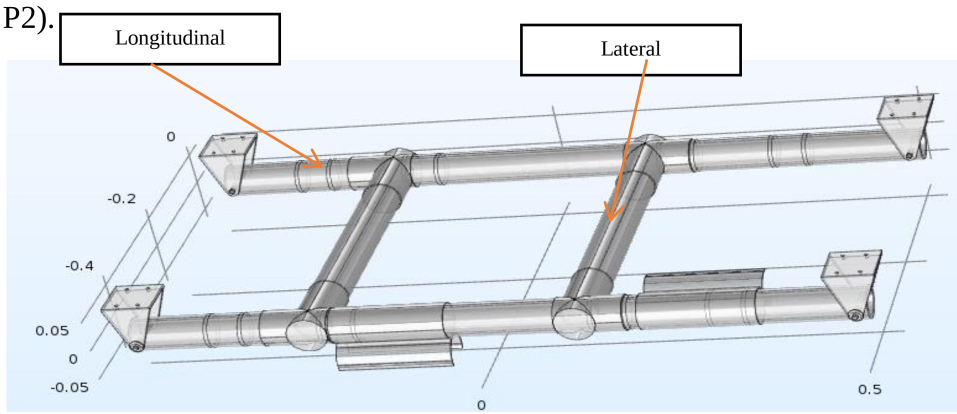

Figure 6: Sketch of H-bar

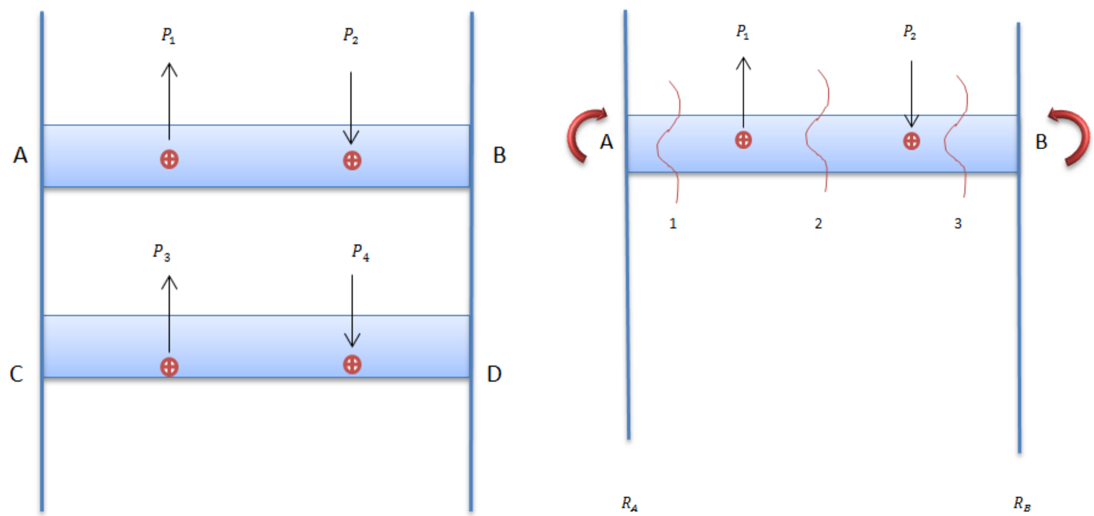

Figure 7: This represents free body diagram of h-bar (Forward Direction) to calculate Maximum Shear & Moment.

After that, section method was used to find shear and moment at different locations of the bar at forward lateral direction. The same process was repeated for the bottom lateral section. This method was used only for X and Z direction. Hence, Y-axis does not create any shear and moment forces.

Subsequently, singularity method was used to find the slope and deflection at different locations of the bar. According to the given conditional load, shear and moment equations were developed by taking double derivatives, which helped to determine the analytical values of slope and deflection towards X & Y direction, as shown in Figure 8.

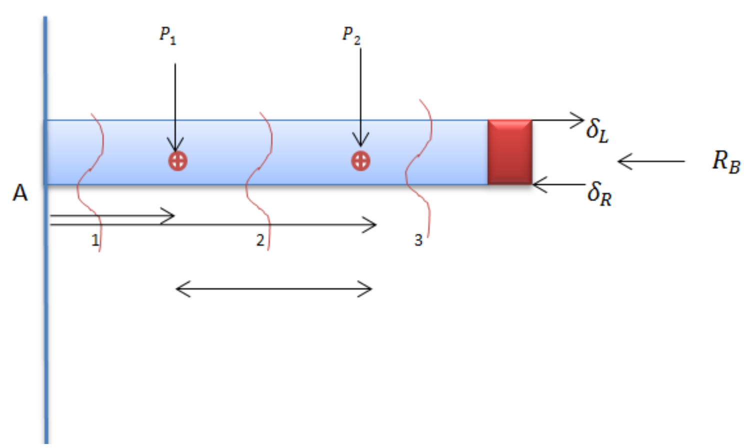

Figure 8: Free body diagram to find total deflection on X-Axis, H-Bar

Once slope, deflection, shear and moment were found in h-bar, maximum stresses were found with the help of the shear and moment body diagram, by applying the given equation in the mathematical section, which related the value with the numerical method used in CATIA V5.

5. Shear & Moment Diagrams of H-Bar

Graph: Shear & Moment Diagram

Longitudinal(X-Direction): Forward

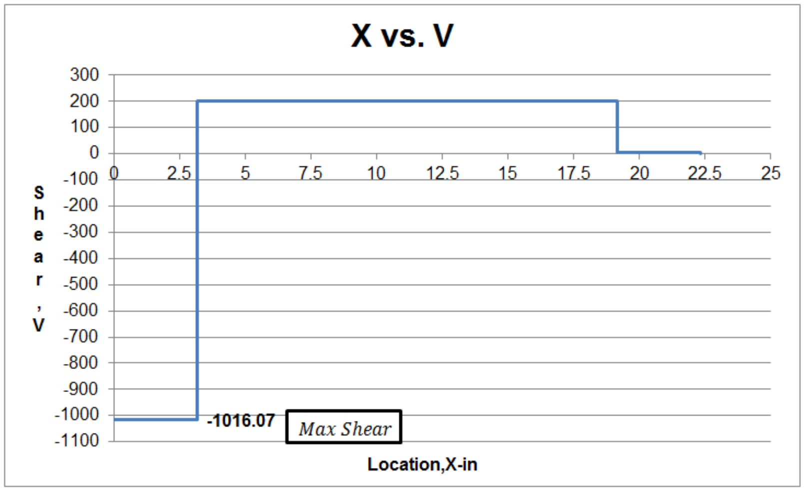

Figure 9: Maximum shear, forward-X-direction, in h-bar

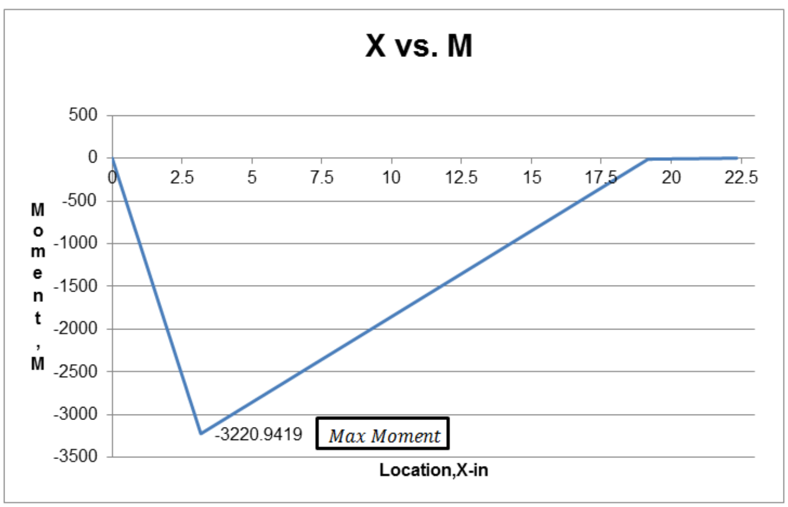

Figure 10: The maximum moment, forward-X-direction, in h-bar

6. Conclusion

The H-bar design was chosen to apply structural analysis according to the standards in the aerospace industry. The whole h-bar structure was designed and assembled in CATIA V5. Then, under specific load conditions, finite element analysis was executed to find the maximum stress location in h-bar. Consequently, in finite element modeling, a finer mesh was being applied to get an accurate solution. As mesh is made finer, the computation time increased in F.E.A workbench. However, a mesh on H-Bar structure was created by using the fewest reasonable number of elements to conduct the analysis. Subsequently, the mesh was recreated with a denser element distribution re-analyzed and compared with those of the previous mesh. The process of increasing the mesh density continued until the results converged satisfactorily.

In the aerospace industry, the structural analysis of side-facing seats is calculated according to 12 standard inertial load cases. Since these seats are combined on both sides, an analysis was conducted to consider the effect of combined load. These loads were applied on h-bar to the lateral side where seats were hanging downward. Therefore, numerical analysis in CATIA confirmed that H-bar structure is safe under applied loading condition. F.E.A workbench helps to understand the whole project from the design process to the Von Mises stress.

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The Effect of the 3-D Printing Process on the Mechanical Properties of Materials

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ABSTRACT

Tensile tests were conducted following the ASTM Standard D3039 for different specimens produced using additive manufacturing. Since the expansion of the 3D printing market, different methods of three-dimensional printing and different materials have been developed. Distinct specimens of varying materials and infill were printed with a consumer grade PLA FDM printer without heated bed, a consumer grade SLA printer, and an industrial manufacturing grade ABS FDM printer with heated bed. The specimens included Polylactic Acid (PLA), Tough PLA, Acrylonitrile Butadiene Styrene (ABS), and black resin. The PLA and tough PLA specimens were printed at infill intervals of 20% and at 0/90 and ±45 degrees with respect to the longitudinal axis. The ABS material was also printed at the same angles with respect to the longitudinal axis at solid(SO), sparse double density(DD), sparse high density(HD), and sparse low density(LO) infill values. The consumer grade SLA printer was used to print specimens using black resin and was divided into two sets. The first set includes specimens that were cured under an ultraviolet light while the second set contained those that were not cured after printing. The overall result showed that the infill and print orientation of ±45 degree performed better for the PLA and Tough PLA material. However, the orientation did not influence the ABS material which may have be attributable to having used an industrial grade 3D printer. In resins, the increase in resolution resulted in a higher ultimate stress, while curing normalized the ductility of the material.

Keywords: Tensile, Additive Manufacturing, PLA, ABS, Resin

1. INTRODUCTION

The tensile test is one of the most fundamental tests used in obtaining the mechanical properties of a material. Additive manufacturing (3D Printing) is the process of producing three dimensional solid objects from a digital file. In one method of additive manufacturing, the object is created by laying down successive layers of material. Popular methods of 3D printing include Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), and Stereo Lithography (SLA). The SLS method involves the use of a high-power laser to fuse small particles of material such as plastic, metal, and ceramic into the desired three-dimensional object. Fused Deposition Modeling uses a plastic filament or metal wire that is supplied into an extrusion nozzle. The extrusion nozzle heats the material supplied and moves in horizontal and vertical directions with a numerically controlled mechanism while controlling the flow of the material exiting the nozzle. This method of 3D printing is seen in products of many companies. The process of Stereo lithography involves a container of ultraviolet curable photopolymer resin and an ultraviolet laser to build the object's layers one at a time. This process is seen in the FormLabs 2 resin printer. With the expansion and growth of different printing processes and methods, there has been very little research on the effect of the printing process on the mechanical properties of the materials available on the market. This paper examines the FDM and SLA methods of printing and their effect on tensile properties of the materials printed. Applications of this work include model prototyping and material selection in production.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

The materials studied in this project were 6.35mm x 25.4mm x 254mm specimens of Polylactic Acid (PLA), Tough PLA, Acrylonitrile Butadiene Styrene, (ABS), and Black Resin. The PLA and tough PLA specimens were printed at infill intervals of 20% and at 0/90 and ±45 degrees with respect to the longitudinal axis. The ABS material was also printed at the same angles with respect to the longitudinal axis at solid(SO), sparse double density(DD), sparse high density(HD), and sparse low density(LO) infill values. The consumer grade SLA printer was used to print specimens using black resin at 0.1 and 0.025-millimeter resolution. The black resin was divided into specimens that were cured under an ultraviolet light and specimens that were not cured. A minimum of four tests was conducted for each chosen specimen type.

2.2 3D Printing Process

In the FDM 3D printing process, the printer first deposits continuous perimeter outlines of the layer being printed. It then deposits the inside of the layer based on infill setting. As can be seen figure 1, the infill value determines how the printer prints the internal structure of the piece. In SLA printing, a UV laser cures a layer of liquid resin which is force adhered to the previous layer. The resulting piece is solid, and only resolution (layer thickness) can be altered. Table 1 shows all specimen types that were analyzed in the experiment.

Table 1 Specimen Material, Infill, and Print Orientation Types

Specimen Types								
Material / Infill	**PLA ($0/90^0$)**	**PLA ($45/-45^0$)**	**Tough PLA ($0/90^0$)**	**Tough PLA (45/-45)**	**ABS ($0/90^0$)**	**ABS ($45/-45^0$)**	**Black Resin (Cured)**	**Black Resin (Uncured)**
	20%	20%	20%	20%	Solid	Solid	0.1	0.1
	40%	40%	40%	40%	Sparse Double	Sparse Double	0.025	0.025
	60%	60%	60%	60%	Sparse High	Sparse High		
	80%	80%	80%	80%	Sparse Low	Sparse Low		
	100%	100%	100%	100%				

2.4 Experimental Setup

The tensile testing machine, Pasco ME-8236 Materials Testing Apparatus, as can be seen in figure 2, was modified to use a DC 12V 3.5RPM High Torque Motor to actuate the tensile machine. The motor was calculated to turn the manual hand crank at the ASTME Standard speed of 2 millimeters per minute. The substitution of the motor also eliminated any possible error resulting from use of the manual hand crank method. The tensile testing machine utilized the software, Pasco Capstone, to record data at a frequency of 5 Hz. In recording data at this frequency, data sets of 500-700 points were recorded. The specimens were printed in sets of four allowing for multiple tests of each sample type. This procedure eliminated major possibilities of error in the sample sets during tensile testing.

Figure 1: 20,40,60,80,100% infill from left to right

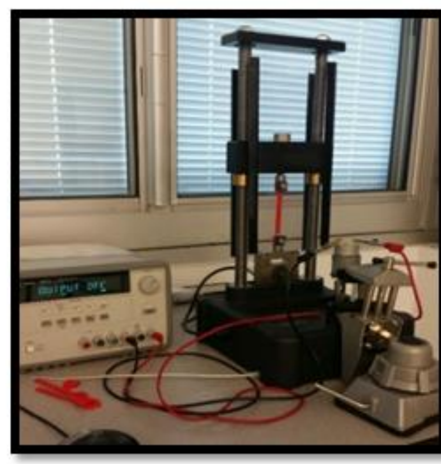

Figure 2: Testing Setup

3. RESULTS

In calculating the stress experienced by the specimen to plot the σ-ε curves, the actual cross section of the specimen was considered. Therefore the 20% infill had a smaller cross-section than the 100% and so on, but the outer width and thickness were the same.

PLA Specimen

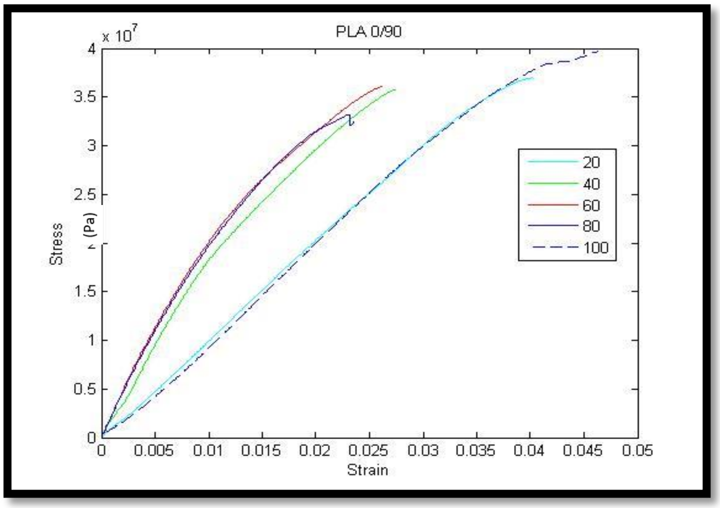

Figure 3: PLA 0/90⁰ Specimen Stress(σ) vs. Strain(ε) Graph

Figure 3 shows tensile behavior of PLA at a 0/90 configuration with various percent infills. The 20 and 100 percent infill behavior present similar configurations attributable to the shelling process of the 3d printer. This machine which prints with 2 continuous outer shells, a process observable in Figure 1. The 20% infill is produced in a diagonal cross pattern, whereas the 40, 60, and 80% are produced in a length-wise grid pattern.

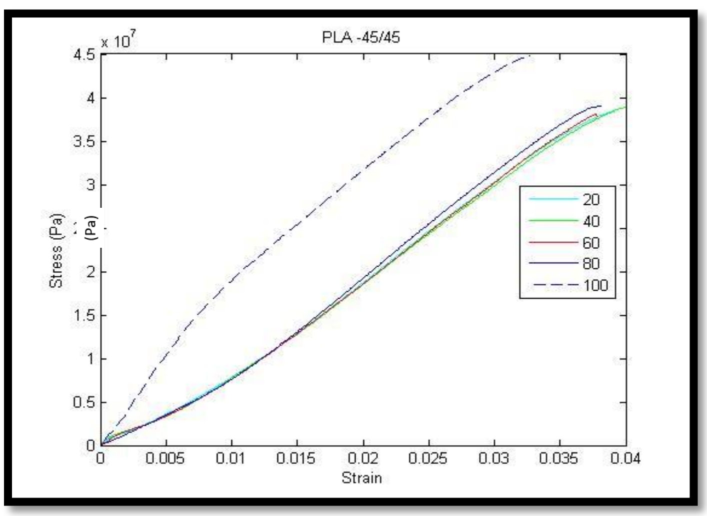

Figure 4: PLA -45/45⁰ Specimen Stress(σ) vs. Strain(ε) Graph

Figure 4 displays tensile behavior of PLA in a -45/45 configuration for the listed infill values. The 20, 40, 60, and 80 percent infill had very similar material behavior attributable to the change in printing direction.

Tough PLA Specimen

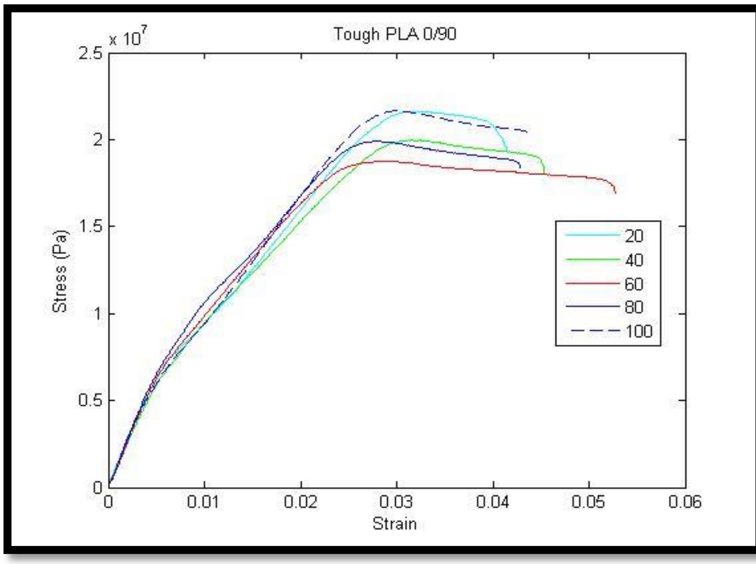

Figure 5: Tough PLA 0/90^0 Specimen Stress (σ) vs. Strain(ε) Graph

Figure 5 shows the longitudinal stress-strain curves for the tough PLA material at the five set infill percentages. The first portion of the test showed that all five tough PLA specimen types exhibit similar behavior under tensile load. As expected, the 100% solid infill specimen had the highest ultimate strength compared to those with a lower infill.

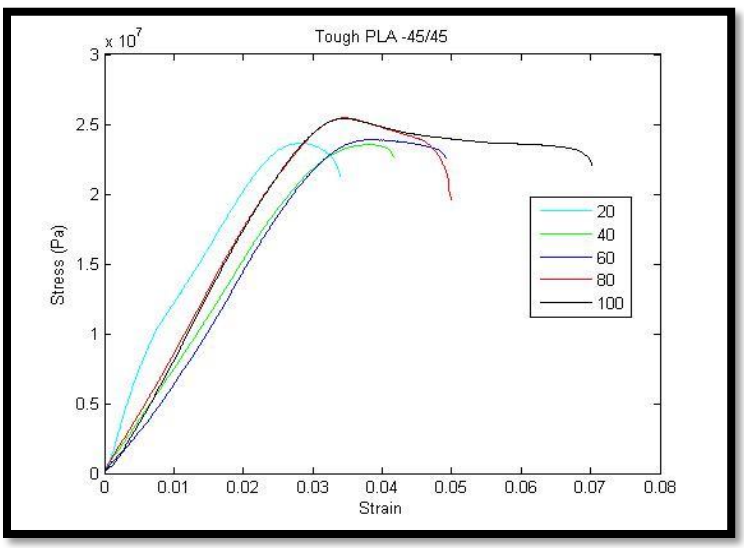

Figure 6: Tough PLA -45/45^0 Specimen Stress (σ) vs. Strain(ε) Graph

Figure 6 shows tough PLA material printed at the -45/45 orientation. The resulting data shows that the 45-degree configuration increased the ultimate strength of the material. In a comparison between Figure 3 and 4 graphs, the angle change in printing resulting in a higher ultimate stress and yield point is observable. The ductility increases with greater infill, unlike the 0/90 configuration which remains similar across most of the infill values.

ABS Specimen

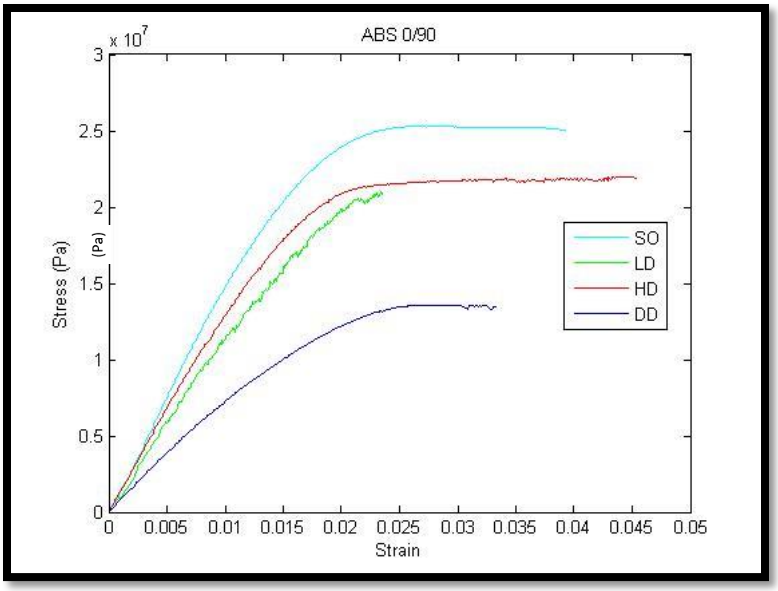

Figure 7: ABS 0/90^0 Specimen Stress (σ) vs. Strain (ε) Graph

The ABS FDM printer provides the options of solid (SO), High density (HD), Low density (LD), and Sparse double density (DD) which follow a decreasing infill in the order listed. It can be seen from figure 5 that as the infill decreases the ultimate strength decreases and produces a reduction of the elastic modulus.

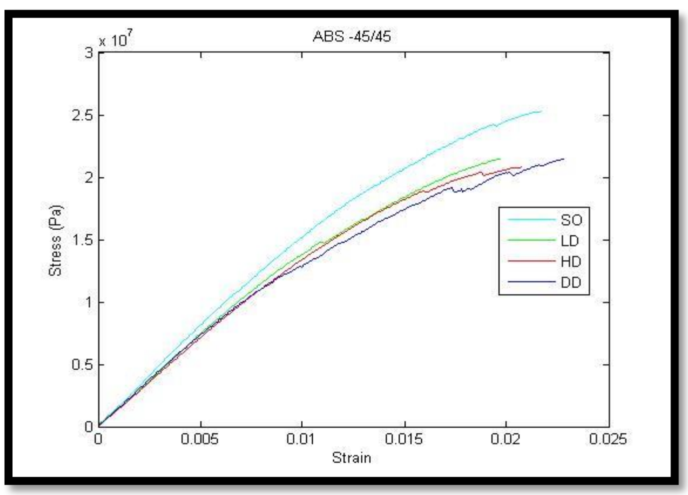

Figure 8: ABS -45/45^0 Specimen Stress(σ) vs. Strain(ε) Graph

As observed in Figure 8, the -45/45 orientation produces a more consistent behavior in comparison to the 0/90 configuration.

Resin

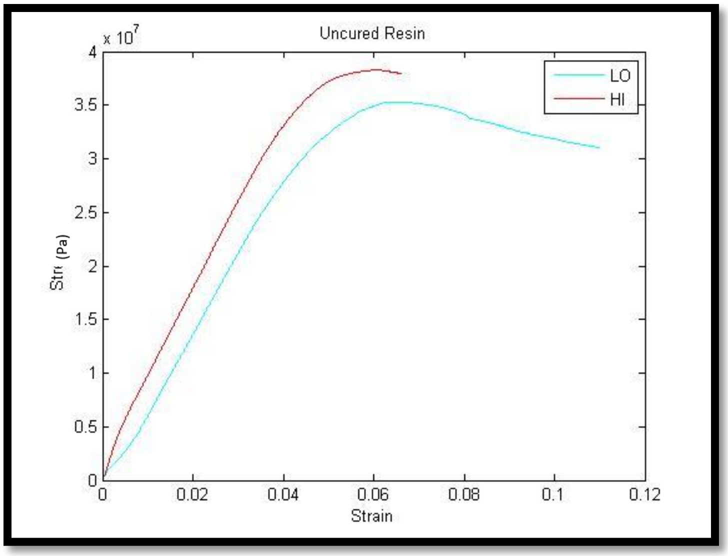

Figure 9: Uncured Black Resin Stress (σ) vs. Strain (ε) Graph

In figure 9, high resolution printing resulted in a higher ultimate strength but lower ductility. This may be attributed to the layer height of the print which is 0.1 mm for low resolution, and 0.025 mm for high resolution. This means there are four times as many layer intersections and therefore four times as many weaker layers of failure.

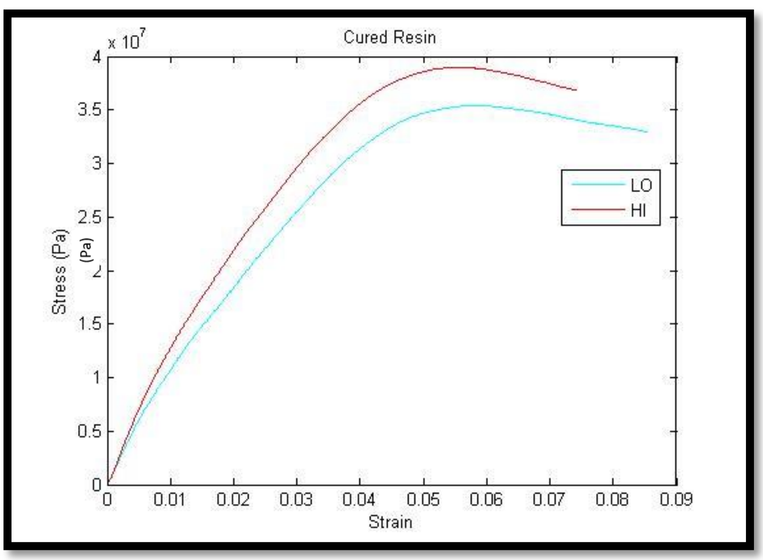

Figure 10: Cured Black Resin Stress (σ) vs. Strain (ε) Graph

Again, in Figure 10, the high-resolution print resulted in a higher ultimate strength, but the act of curing appears to stabilize the layers and even the ductility. The low resolution became more brittle while the high resolution became more ductile.

Table 2: Tensile Properties of Each Material Configuration

Tensile Properties of Each Material Configuration					
		Elastic Modulus (GPa)	**Sigma Max (MPa)**	**Yield Point (MPa)**	**Ductility**
PLA 0/90⁰	**20%**	0.9095	36.971		4.03%
	40%	1.8573	35.745		2.74%
	60%	2.2815	36.089	22.81	2.61%
	80%	2.207	33.2	21.54	2.35%
	100%	0.8004	39.673		4.63%
PLA - 45/45⁰	**20%**	0.6475	38.349		3.91%
	40%	0.5812	38.845		4.00%
	60%	0.6205	38.093		3.78%
	80%	0.6926	39.026		3.82%
	100%	2.1316	44.836	22.52	3.27%
Tough PLA 0/90⁰	**20%**	1.2648	21.619	8.734	4.16%
	40%	1.1739	19.965	9.289	4.54%
	60%	1.2767	18.763	9.421	5.28%
	80%	1.3224	19.901	10.65	4.29%
	100%	1.2333	21.64	8.325	4.41%
Tough PLA -45/45⁰	**20%**	1.5632	23.638	10.201	3.40%
	40%	0.7233	23.539	23.01	4.16%
	60%	0.5584	23.892	23.63	4.91%
	80%	0.8185	25.46	25.23	5.00%
	100%	0.8332	25.414	25.29	7.02%
ABS 0/90⁰	**Solid**	1.5132	25.301	21.5	3.93%
	Low Density	1.212	20.972	16.99	2.36%
	High Density	1.3688	21.959	17.85	4.54%
	Double Density	0.779	13.57	9.766	3.33%
ABS -45/45⁰	**Solid**	1.6317	25.276	19.99	2.17%
	Low Density	1.4753	21.486	19.18	1.97%
	High Density	1.4243	20.796	18.55	2.07%
	Double Density	1.4797	21.438	14.57	2.28%
Uncured Resin	**Low Resolution**	0.5662	35.338		11%
	High Resolution	1.1965	38.295	10.57	6.59%
Cured Resin	**Low Resolution**	1.2334	35.394	12.91	8.53%
	High Resolution	1.4595	38.967	15.39	7.42%

Table 2 shows a summary of all the results obtained from the testing of specimens produced by additive manufacturing.

4. CONCLUSION

The tensile testing shows that the infill and orientation of 3D printed materials effects the tensile properties of the material. The ±45 degree samples performed with an overall higher ultimate strength in both PLA and Tough PLA. The orientation had little effect on the ABS. This may be attributed to the grade of printer used i.e. consumer grade vs. industrial grade. In resins, a higher resolution equated to a higher ultimate stress, and curing of the resin normalized the ductility of the material.

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Multi-Robot Framework For Collaboration Between Heterogeneous Robot System Software Development Kit

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ABSTRACT

This project is dedicated to consolidating software packages and tools used in Mobile Robotics (Ground and Aerial). Together these resources produce an open source software development kit for the expansion of applications requiring multiple and different type of robots. The idea is to employ the specific strengths of individual robots together in order to achieve a task. This approach opens the door to applications that individual robots can achieve while working as one.

1. INTRODUCTION

In today's rapidly growing and innovative world, we are using robotics in different ways to accomplish a multitude of tasks. Because of their ability to work repeatedly, accurately, and in many different environments, robots are chosen over humans for many tasks. Autonomous robots require substantial computation to sense the environment and to act in response to their limited sensors and capabilities. Robots are also dependent on their location and environment. Using the necessary hardware and software, robots can complete specific tasks. As hardware capabilities advance, such as processing speed, the software to control these robots becomes necessary. Multi-robot systems are the next step in the evolution of autonomous robotic systems.

2. PROBLEM STATEMENT

Robot Operating System (ROS) has become a standard in the robotics community. These drivers, algorithms, tools, libraries, and conventions are aimed towards simplifying and creating complex robotic behavior across a wide range of platforms and applications. ROS is open source, where users have access to change and update projects.

ROS also provides simulations platforms to test software before implementation on actual robots. Simulations are very important to debug code and determine correct operations. If a problem occurs with the actual robot and a simulation is running correctly, the user can conclude that a hardware issue is involved. While simulations provide useful software information, they do not exactly replicate the real-world result.

ROS-based frameworks for multi-robot systems are scarce and proprietary and hardware dependent. There are few resources available to combine the multiple packages required in the navigation, mapping and communication required for a multi-robot system.

3. OBJECTIVE

The objective of this project is to create a framework that will provide tools to produce a multi robot system, while also simplifying the ability to use ROS. The framework consists of created tools necessary for robots to work together including: mapping, navigation/path planning, obstacle detection/avoidance, etc. The framework will be built with ROS so that one is not restricted to use of only the provided tools. Instead the user will be able to use ROS tools throughout the internet to connect sensors and actuators to a robot. This framework also considers the necessary communication for the robots to send information to one another. As observable in Figure 1, each individual robot operates its own ROS system. Figure 2 displays only one ROS in operation on any of the robots, and how each robot sends the information to the others. In this manner, multiple robots work together to achieve a task determined by the user. As a test, a multi-robot system formed by an aerial robot and ground robots is examined.

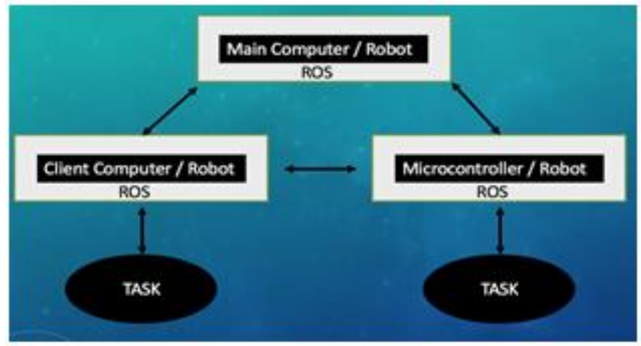

Figure 1. ROS Architecture with Multiple ROS

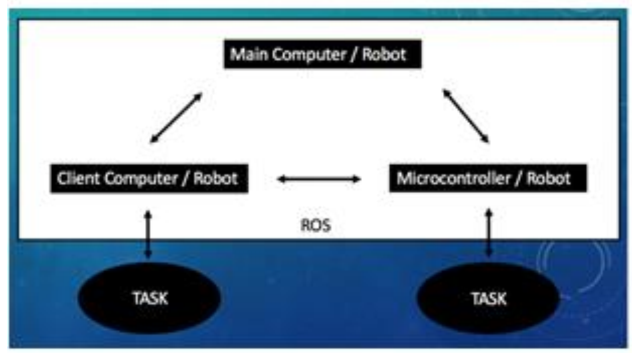

Figure 2. ROS Architecture with one ROS

4. SOFTWARE DEVELOPMENT KIT DESIGN

4. 1 Robotics Tools

The tools found here are used throughout any type of robot and require the robot to have an onboard computer running a Linux Distribution and ROS installed. The basic ROS architecture is made up of packages with nodes (publishers, subscribers), topics, services, and messages. To send data, we must "publish" the data to a specific topic. In order to read or input data one must "subscribe" to a topic. Topics are used to exchange messages across different systems. A service is like a topic within which a system exchanges messages, but when a system uses a service to send a message that system waits for a reply before completing a new action.

4.1.1 Computer Vision

Part of this framework we include some vision capabilities. A popular ROS Package using computer vision is detecting apriltags. Apriltags, like QR codes are 2D barcodes with an individual shape and signature. In research situations apriltags could be placed on objects that a robot could detect. Based off what you save the tag to be, when a specific tag is detected the robot knows whether it is an obstacle, object to pick up etc. The apriltag package includes all the apriltags and when running individual shape and signature. In research situations apriltags could be placed on objects that a robot could detect. Based off what you save the tag to be, when a specific tag is detected the robot knows whether it is an obstacle, object to pick up etc.

The apriltag package includes all the apriltags and when running this package, the package will be able to detect which tag has been detected and its location on the screen. Another portion of computer vision is the implementation of OpenCV. OpenCV is a library of programming functions mainly aimed at real-time computer vision. It was originally developed by Intel's research center in Nizhny Novgorod (Russia). One of the useful tools in OpenCV is its color and shape detections. There tools can help the robot detect its location referenced to its frame. OpenCV is a C/C++ Library which is downloaded on to the computer that is using it. The C++ code to detected shapes and colors are converted into a ROS package by creating a ROS workspace and publishing the detected objects location on the screen and color detected. This can be changed depending on what information is more valuable for the application.

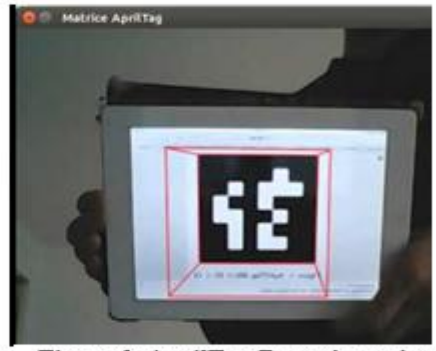

Figure 3. AprilTag Detection using AprilTag ROS

Figure 4. Detecting Shapes and Colors with OpenCV

4.1.2 Communication

For this framework, it is essential that all robots in the system communicate with each other. This applies for a system that has either two robots or twenty robots, communication between the robots is a vital step to accomplish any task or goal. For this framework, the robots are configured to work on an ad-hoc network. An ad-hoc network allows machines to directly communicate with each other without the use of a router. This allows more flexibility because if another robot enters the system no configuration by a router is needed. The ad-hoc communication allows packages to be exchanged over several roscores or ROS systems by transmitting data to a specific destination and publishing that data on a predefined topic at the destination host. Unlike using a router for communication and

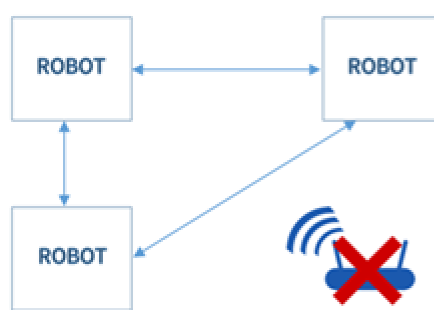

Figure 5. AD-HOC Communication

the IP address of the robots, communication is accomplished through use of the predefined hostnames. After the ad-hoc network is set up and functional, basic tests are completed to ensure that all robots are correctly communicating with each other. The first basic test is to ping between each system in order to verify communication between robots. Upon successful completion of that test, the robots' ability to send and receive information is then conducted. In multi-machine communication, one robot operates as a talker while the other robot operates as a listener waiting for commands. The robots must have a bi-directional connectivity between all ports. One rocsore is then launched on the talker or master robot. Whatever node or nodes that are published by the master, the listener robot can then see and access for later use.

To keep track of multiple robots within a coordinate frame the ROS tool tf2 is utilized. The ROS tool tf2 allows the user to transform points and vectors between any two coordinate's frames at any point in time. This means that any information needed regarding the robot's whereabouts, referenced within the global frame, can be discovered. As previously described, there is a master robot broadcasting its movement or transformation; this robot sends out information regarding its pose of coordinate frames relative to its global frame. Then another robot waits and listens for that information. When the listener receives that information, the robot will move to that broadcaster's previous position. This allows the robot to follow the master robot across the coordinate frame.

4.2 Aerial Robots

To achieve autonomous flight, aerial robotics has shifted to using flight controllers and using a protocol known as MAVlink [1]. Some of the most popular flight controllers today are the APM and Pixhawk running either the ardupilot or PX4 firmware stack [3]. These flight controllers handle all flight capabilities, control systems and interfacing to electronics. Some of the necessary electronics required on a robot are a Lidar Rangefinder (Lidar Lite V3) and an Optical flow sensor (PX4FLOW) [4][8]. The Lidar Lite is used in measuring the distance off the ground. The optical flow sensor consistently takes pictures of the ground, extracts information on its current location, and fuses data with the inertial measurement unit and controls, in order to maintain a steady position. It is essential to use both sensors in an aerial robot to achieve a stable hover. The use of a GPS in outdoor situations is also recommended. The protocol MAVlink, consists of 17 bytes and includes the message ID, target ID and data.

Figure 6. Flight Controllers. Pixhawk(Left), APM(Right)

Figure 8. Lidar Range Finder – Lidar Lite V3

Figure 7. Optical Flow Sensor – PX4FLOW

The message ID shows what the data is and can be seen in the message ID command set. This enables MAVlink to be able to send and get information from multiple UAVs if messages are transferred in the same channel. Messages can be transmitted either through wireless signals, UART or USB. ROS has a package known as MAVROS that converts code into MAVlink information for the aerial robot [2]. This package provides and sends robot information. The MAVROS topic used to control the movement of the robot is "/*setpoint_raw/local*". A location must be sent for the robot to follow in x, y, z coordinates (meters) and yaw angle (radians). In order to move the aerial robot, one must first arm it with the service "/*cmd/arming*" and use the service *"/set_mode"* to change the robot's mode to off board. The robot will then be enabled to publish its own commands to move in the required directions.

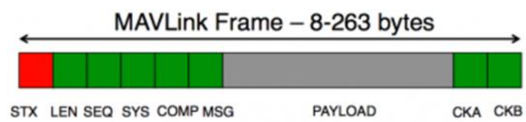

Figure 9: MAVLink Message Format

4.3 Ground Robots

There are many options when building and programming ground robots. One option that can be used with this software development kit is the GoPiGo board from Dexter Industries [7]. This board uses a ATmega328P Microcontroller for motor control and sensor I/O and acts as an interpreter for the Raspberry Pi 3. The operating system installed on Raspberry Pi 3 is a Linux based system called Ubuntu Mate 16.04. The Raspberry Pi 3 also has the ROS tools needed to program the GoPiGo. A ROS tool called ROSARIA allows communication and an interface between robots. ROSARIA node allows information like velocity and acceleration to be sent to the robot. ROSARIA also allows information from an external sensor to be accessed. This is helpful for any obstacle avoidance that the robot may need. Using ROSARIA makes programming the GoPiGo robot easier because all that is needed to program the robot are the parameters given from the ROSARIA node.

Another completely different robot called the Pioneer 3-DX can be programmed [5]using this same software development kit. The Pioneer 3-DX is a compact differential-drive mobile robot that is used for mapping and navigation. It has eight forward and eight rear-facing sonars, and can carry a payload of up to 17kg.

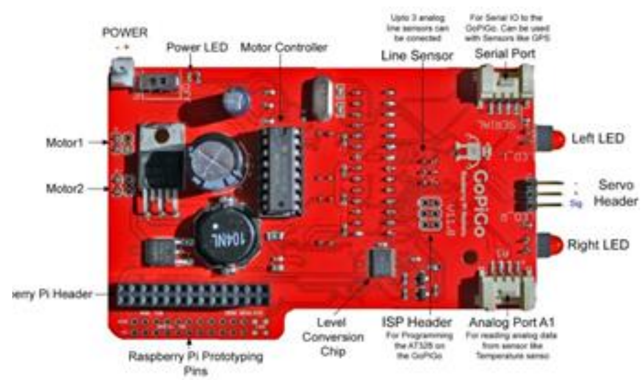

Figure 10. GoPiGo Board

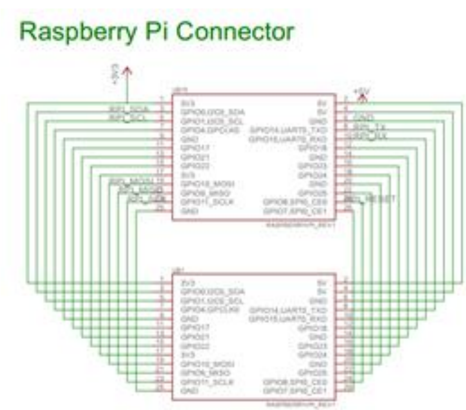

Figure 11. Raspberry Pi Schematic

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This robot has a different microcontroller from the GoPiGo; however, the software development kit simplifies programming of the Pioneer 3-DX. Communication and programming for the Pioneer 3-DX is all done using the ROS tool, ROSARIA. All that is needed is the local port for the Pioneer 3-DX, and it can be programmed similar to the other robot.

Figure 12. Pioneer 3DX

Before implementing the program on actual robots, the programs can be tested on a virtual simulator tool called MobileSim. MobileSim is software used for debugging and experimentation with ROSARIA [6]. The codes written for the robots are first tested on MobileSim in order to understand what to expect when the program is implemented on actual robots. This software was used to test the tf2 tool previous discussed. Two robots were placed in a map, and one robot was told to generate a random path around the map. The second robot then used the tf2 protocol to follow the first robot. Then to implement the code on an actual robot, the only necessary change is the TCP Port for the robot. The change in TCP port informs the ROS that this code is being used for actual robots, rather than a simulation. This software development kit allows easy programming of any robot with any microcontroller.

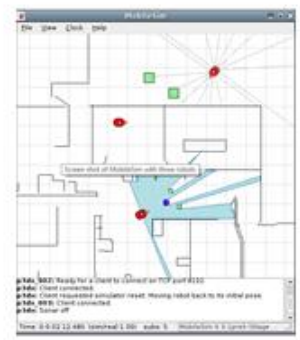

Figure 13. MobileSim Simulation

5. CONCLUSION

In the creation of this framework, individual robots may be used to work together for completion of a task. These various tools hold the necessary capabilities for the creation of different robotic applications. The Github repository dispays this entire project, thus enabling the open source community to use the tools as well as to contribute to the project. The flexibility of this software development enables its use for any mobile robot project. The architecture design of this framework also permits easy implementation within any robotic system.

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A Novel Use of Thermo-Electric Generator (TEG) Based on Availability of Heat Source

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ABSTRACT

One of the major issues facing our society today is environmental pollution and the devastating effects it has had on climate over the past century. Over the past decades, much time and effort have been invested in energy recycling and in finding sources of renewable energy to address this problem. The aim of this project is to explore and analyze an environmentally friendly option for generating electricity from thermal energy through the use of thermoelectric generators (TEGs). Thermoelectric generators are solid-state devices that recover useful thermal energy through the function of thermoelectric modules; the modules convert waste heat energy into electricity through a concept known as the Seebeck Effect. The Seebeck Effect states that if the TEG element is exposed to a hot side and a cold side, the flow of heat from hot to cold can be used to generate electricity. The greater the temperature differential (delta Temperature) across the module from the hot side to the cold side, the greater amount of power which can be produced. A model generator will be created and used to power a 5V/2A battery pack to charge small electronics such as a mobile phone.

1. INTRODUCTION

Thermal energy has been utilized by mankind longer than most other forms of energy. For centuries, people have created thermal energy as either an end-product or by-product of another related process. Fire is one such example, in which thermal energy is generated from a chemical process or chemical energy. Friction is another example; heat is generated from mechanical energy. It is possible to reverse this process and use heat, or thermal energy to generate an alternate form of useful energy. One such case where this is possible is in the use of thermal energy to create electrical energy.

Thermo-electric generators (TEG) are instruments that directly convert energy from thermal to electrical. The concept behind this energy conversion is known as the Seebeck effect. TEG's have great potential when it comes to waste heat recovery. There are numerous advantages to using TEG technology including the lack of moving mechanical parts, longevity, low maintenance, noiselessness, and environmental friendliness [1]; the latter is especially important in today's world, considering that the full effect and dangers of global warming are starting to be realized.

A significant contributor to environmental pollution and global warming has been the internal combustion engine (ICE). The internal combustion engine operates and/or drives vehicles with only about a 30% efficiency. This means that close to 70% of the heat generated by the fuel used to power the engine is lost and thus wasted; of the 70%, 40% of the heat is lost through the gas exhaust and 30% through the coolant [2]. Through the use of TEG's, this automobile heat waste could be used to reduce ICE fuel consumption and environmental pollution as well as the loads on the vehicle alternator. In fact, automobile manufacturers such as GM and BMW have invested and successfully developed TEGs to recover the exhaust waste heat [3] [4]. However, due to limitations of the TEG materials and the complexity of the automobile system, the TEG systems have been limited overall to less than 5% efficiency and thus more research is needed in this field.

For the purposes of this study, a small TEG test system will be developed and adopted to charge a 5V power pack. This power pack will later be used to provide electrical charge to a phone through a USB port. The chip(s) that will be used are designed by the TECTEG and are already programmed based on the input to generate electricity. The thermoelectric module will be developed both physically and through CAD design software. The module will be tested under different conditions, with a constant heat source and with a variable heat flux thermal source. Data will be collected and analyzed, and the system will be tested under different conditions for comparison. Further applications and possible improvements will also be presented.

BACKGROUND

It is important to explain the thermoelectric effect, as the Seebeck effect is one of three separately identified thermoelectric effects. A thermoelectric effect is the direct conversion of a temperature gradient into an electrical power output and vice versa. This means one of two things; first, when there is a temperature difference on either side of a thermoelectric device, a voltage will be created. Secondly, as this process is reversible, if the voltage is applied to the thermal electric device, the temperature gradient will be created. Thermoelectric modules can therefore be used for electricity/power generation and temperature control/measurement.

The Seebeck effect is often referred to as the Peltier-Seebeck effect. This is in reference to the Peltier effect, which is basically the thermodynamic reversal of the Seebeck effect; the two processes were thus named because they were discovered separately by different physicists, Jean Charles Athanase Peltier and Thomas Johann Seebeck.

The Peltier effect refers to the creation of a temperature gradient at an electrified junction of two conductors. This concept is useful when the objective is to transfer heat from one medium to another. Thermoelectric heat pumps and cooling devices found in refrigerators operate on this concept and usually involve multiple junctions connected in series; an electrical current driven through these junctions will result in heat loss in some and heat gain in others.

The Seebeck effect takes advantage of a temperature gradient at the junction of different types of conductors to generate electricity. This occurs because the electron energy levels of the different materials shift independently and from each other when heat is applied to one of the conductors leading to a voltage difference between the conductors and the creation of an electrical current. The greater the temperature gradient/delta, the greater the amount of generated power.

2. MATERIALS AND METHODS

The main component of our design will be the TEG module/chip. The TEG module is what will allow us to generate voltage using a thermal energy source through the previously described Seebeck effect.

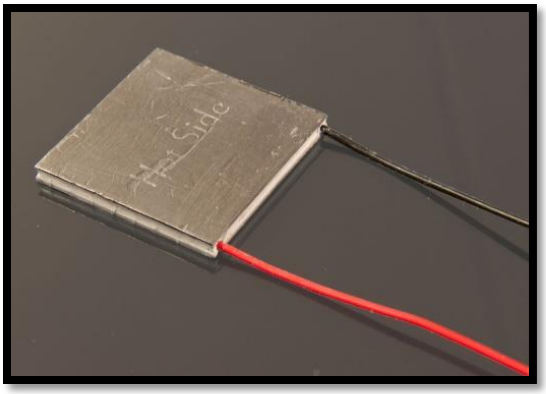


Figure 1: TEG Module/Chip

A thermoelectric generator is made of many pairs of p-type and n-type elements. The p-type elements are made of semiconductor materials doped so that the charge carriers are positive (holes) and Seebeck coefficient is positive. The n-type elements are made of semiconductor material doped so that the charge carriers are negative (electrons) and the Seebeck coefficient is negative.

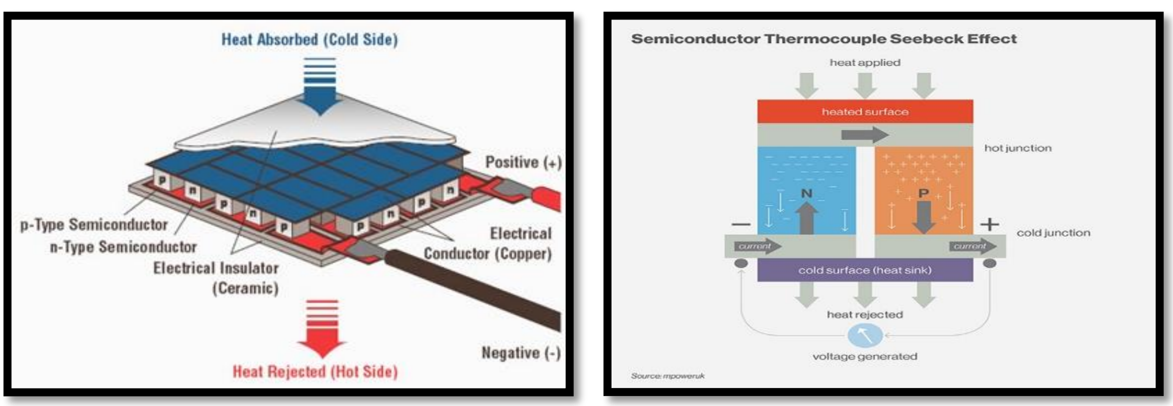
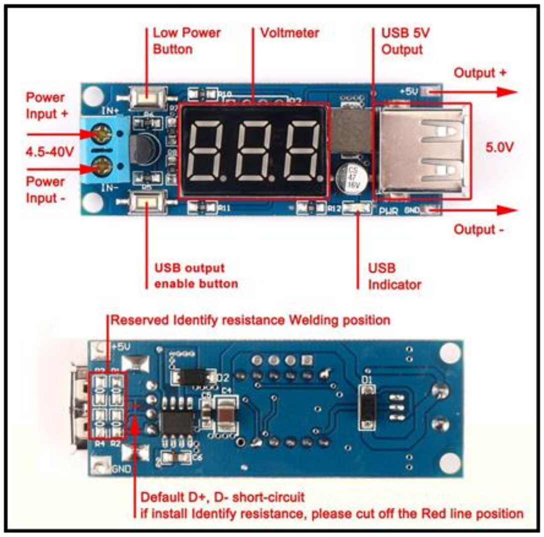


Figure 2: Inside Mechanism of a TEG Module

2.1 Voltage Transformer, Stabilizer, Voltage Regulator USB output Switch

The prototype test unit has 6 TEG chips and the voltage output will vary depending on the temperature differential. As previously identified, the power output needed is 5V/2A to charge the battery pack. To ensure the 5V/2A output, a voltage switching regulator is used (Figure 6).



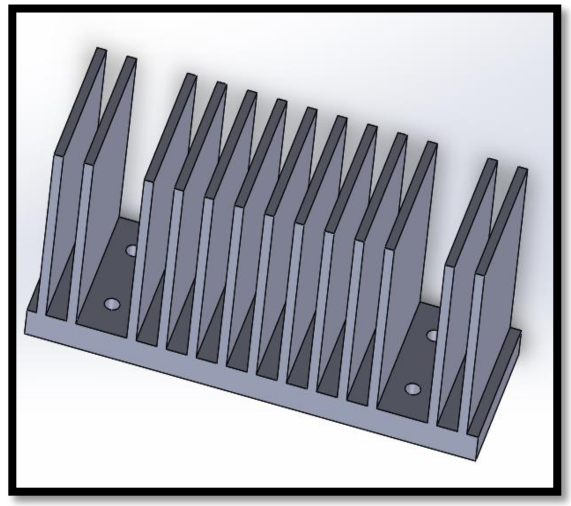


Figure 6: Voltage output regulator **Figure 7: Aluminum heat sink**

The voltage regulator is a special voltage switching regulator manufactured by DROKE. It allows minimum voltage input of 4.5V to maximum voltage input of 40V, and the output power is a steady 5V/2A. There is a meter display embedded to constantly reveal the voltage input.

2.2 Heat Sink

A heat sink is a thermal conductive metal device designed to absorb and disperse heat away from a high temperature object. Heat sinks will be used for our design. They are reliable, as they have no mechanical components. Passive heat sinks are usually made up of aluminum or copper and dissipate heat through convection. Additionally, for a passive heat sink to work at full capacity there needs to be a steady air flow moving across the fins. The heat sink that will be used in this project is an aluminum heat sink (Figure 7).

2.3 Aluminum Plate

An aluminum plate was chosen as the base on which the TEG modules would be mounted, (Figure 8). The use of aluminum in objects of everyday use is economical, safe, and ecologically sensible. *Aluminum* is the most used metal after steel, and it can withstand extreme temperatures without compromising its properties. In extreme cold, aluminum becomes even tougher and its hardness increases. For the purposes of this experiment, aluminum's light weight (three times as light as steel) and its heat conduction properties were of interest.

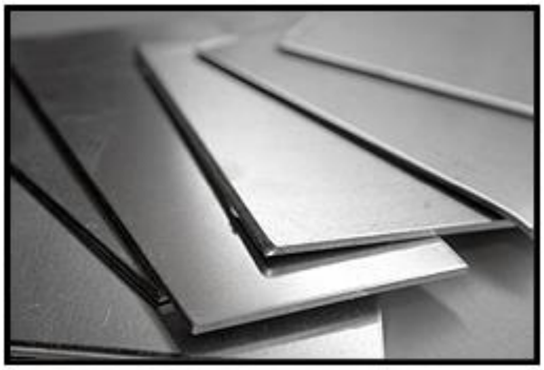


Figure 8: Aluminum plate **Figure 9: Thermal paste**

2.4 Thermal Paste

After initial trials, it was determined that thermal paste would be needed to improve the thermal contact between the elements. Thermal paste was applied on the surface of TEG modules as well as on the heat sink surface to obtain a more optimal conduction of heat through the components. The thermal paste chosen has high thermal conductivity of 3.17 W/(m-K), and its long-term operating temperature is between -30˙C to 240˙C (Figure 9).

3.0 Identifying Needs and Requirements

In order for the TEG module to function correctly, there needs to be a temperature differential established between the "hot" surface and the "cold" surface of the TEG chip. The temperature differential (delta) needs to be such that enough power is reliably generated. To create this temperature gradient across the TEG module, one side must be heated while the other side must be cooled. Once the process for generating electrical power is established, it needs to be modified and adopted so that a 5V/2A battery pack is sufficiently charged to provide power to an electrical device.

Two critical factors affecting the amount of power generated are:

1. Temperature Difference – the temperature of the hot side minus the temperature of the cold side;

2. The amount of heat that flows successfully through the module (Heat Flux).

Emphasis must be placed on both the heat input design and the heat removal design. The more efficient the unit is at moving heat from the hot side to the cold side and dissipating that heat once it arrives to the cold side, the better the results will be, in terms of power generation.

3.1 Design Concepts

The first variable taken into account when designing the thermoelectric test model unit is the size of the TEG chip. The orientation and fitment of the TEG between an aluminum plate and the heatsink must be carefully crafted so as to avoid any heat loss and possible distortion of the results. Choice of the right material for the insulation for the chip is the next factor to be considered, in order to optimize results. The heat source itself need to be determined: either a constant heat source, with a constant and/or controlled temperature difference (hot/cold water), or a heat flux thermal source (heat coil) in which there are variances in the temperature. From the hypothetical CAD model, a physical model must be developed and tested to determine the reliability and/or efficiency of the design.

3.2 Initial Testing

The first test to be conducted is to determine how many TEG modules are necessary to achieve the desired output of 5 volts in our device. Testing was done with only one TEG module to determine the amount of voltage that it generated. The TEG module was placed on an aluminum plate of 0.04-inch thickness and surrounded with foam insulation. A heat sink was placed on top of the TEG module to aid in dissipating the heat from the TEG. The heat sink was secured using an eye screw to pin it down to the TEG module and the aluminum plate. The plate was then placed on an electric hot plate with 4 settings of heat input.

Due to the eye screw securing the hot sink to the rest of the set-up, the plate could not be properly placed onto the hot plate, due to slight bending. Therefore, a second aluminum plate was placed underneath to provide support and an even surface for the unit to rest upon the hot plate.

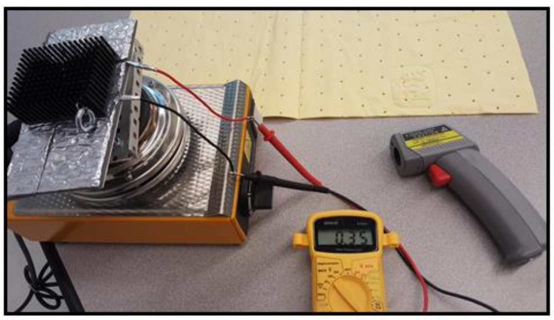


Figure 4: Initial testing setup with one TEG module

The initial test did not yield the desired results. The voltage output being generated was minimal and below the specified output from the TEG module manufacturer. The results yielded are found in Table 1.

Table 1: Results from Initial Test with initial testing configuration (one TEG module)

Setting	Temperature Upper Plate Surface (°C)	Temperature Lower Plate Surface (°C)	Voltage Output
1	52	160	0.37
2	54	187	0.4
3	56	217	0.45
4	61	223	0.48

Since the results from the initial test were significantly less than the desired results, a possible explanation was that the less optimal results were attributable to poor contact between the different elements of the testing unit. The unit was re-tested, this time with pressure being applied onto the heat sink, further pushing down against the TEG module and the aluminum plate. This second test yielded much better results, closer to what was expected based on the technical specifications of the TEG module (Table 2).

Table 2: Results from Second Test with initial testing configuration (one TEG module)

Setting	Temperature Upper Plate Surface (°C)	Temperature Lower Plate Surface (°C)	Voltage Output
1	39	91.2	1.05
2	54	115	1.24
3	62	124	1.38
4	71	136	1.41

To account for the contact problems being experienced, heat paste was added to the configuration to provide better thermal contact between the components, i.e. aluminum plate, TEG module and heat sink. The hot plate being used was modified so that heat input, Q (number of watts being applied to the unit), could be controlled. The hot plate now employed was the heat insert flat plate from the free and forced conversion unit found in the university thermo-fluid laboratory.

3.3 Improvement

Once heat paste was acquired, a second testing unit with one TEG module was built. Heat paste was applied between the TEG module and the aluminum plate as well as between the TEG module and the heat sink. The heat sink was changed from the original testing configuration, with a bigger sink used to provide better heat dissipation. Furthermore, with heat paste being applied, there was no need to clamp or screw down the heat sink onto the aluminum plate. Eliminating the use of the screw used in the original application allowed for the aluminum plate to be placed directly onto the hot plate, theoretically aiding in the improvement of the results.

The new configuration did indeed improve the results over the previous configuration; an increase in voltage output was found with this improved testing unit. This new unit produced a maximum voltage output of 2.4 volts, compared with 1.41 volts generated from the second test with the initial configuration (Table 3).

Table 3: Results from one TEG module with improved testing configuration

Heat Input, Q (Watts)	Temperature Upper Plate Surface (°C)	Temperature Lower Plate Surface (°C)	Voltage Output
50	31	28	0.52
75	39	29	0.81
100	51	30	1.3
125	65	30	1.7
150	84	31	2.1
175	96	32	2.4

These figures would be used as a benchmark from which to compare voltage output vs heat input for all future testing. Progress could be made towards a unit with six TEG modules, to generate the 5 volts needed to charge the battery pack. Six TEG modules were chosen as the next desired configuration based on the result of 2.4 volts generated with one TEG module. With each additional TEG module added to the unit, the voltage output return would decrease (efficiency would decrease). Therefore, six units were determined to be an adequate number of TEG modules to generate the desired output.

3.4 Testing with Six-TEG Modules

Initially the testing unit configuration for the six TEG modules was built using the same aluminum plate as had been used with the improved configuration with one TEG module. However, it was found that the aluminum plate was too thin as it started to curve with the weight of an additional heat sink needed for the six TEG module configuration. This curve created an uneven contact surface with the hot plate as well as between the aluminum plate itself and the TEG modules.

The thickness of aluminum plate used for testing the six TEG module configuration was changed from the original 0.04-inch plate to a 0.125-inch aluminum plate. Thermal paste was applied at every contact point between the TEG modules and the aluminum plate and between the TEG modules and the heat sinks (Figure 5). The results from the final testing configuration are recorded in Table 4.

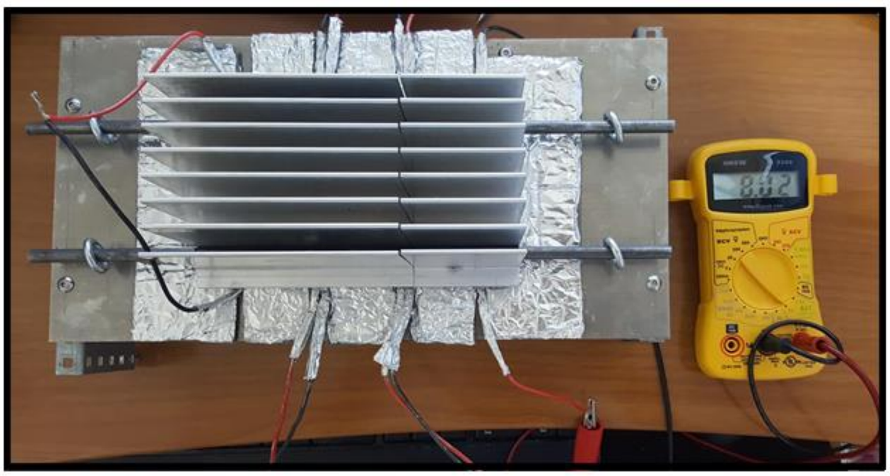


Figure 5: Six TEG module final testing configuration

Table 4: Results from 6 TEG chip modules

Heat Input, Q (Watts)	Temperature Upper Plate Surface (°C)	Temperature Lower Plate Surface (°C)	Voltage Output
50	32.6	25.5	1.46
75	39.7	29.2	2.29
100	49	35	3.29
125	58.5	38.4	4.06
150	73	44.4	5.44
175	85	54.7	7.0

4. RESULTS

4.1 Benchmark performance Heat input vs Voltage output

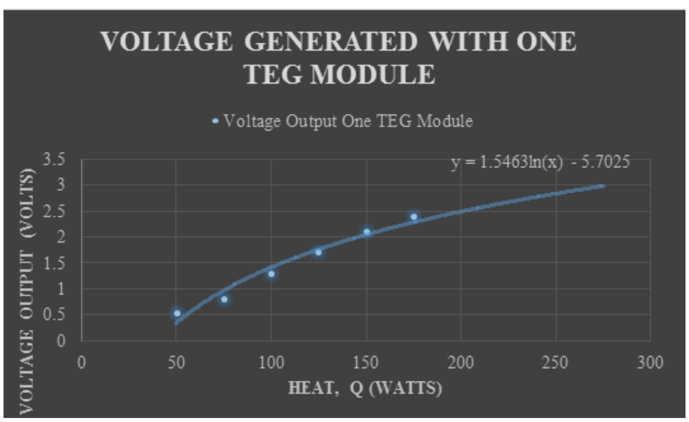
Testing with the improved configuration for one TEG module yielded the results recorded in Table 5. It was necessary to obtain a benchmark equation showing the relationship between the heat input and power voltage output. Obtaining this equation would allow the comparison of the outputs of the six TEG module to the one TEG module and see how it changed, if at all. This benchmark equation would also allow the estimation of the heat input from the voltage output when the flame or steam pipe heat source was used with the future model in which there would be no control over the heat being put into the system.

Table 5: Voltage generated from one TEG modules

Heat, Q (Watts)	Voltage Output (Volts)	Temperature Lower Plate Surface (°C)	Temperature Upper Plate Surface (°C)
50	0.52	31	28
75	0.81	39	29
100	1.3	51	30
125	1.7	65	30
150	2.1	84	31
175	2.4	96	32

Table 5 shows the voltage output readings obtained at six different heat levels from the unit with one TEG module. The readings were recorded at intervals of 25 Watts and were the average of three separate readings as the system was allowed to stabilize at each point.

To establish a benchmark equation, the data recorded in table 5 was plotted in Excel. Using the Excel software, an equation for a best fit line that represents the data points could be determined. The plotted data is shown in Graph 1.



Graph 1: Voltage generated from one TEG modules

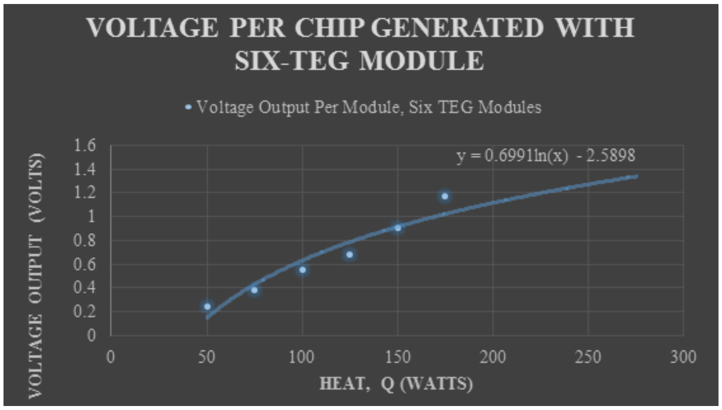
Graph 1 shows the voltage output that was obtained from the trial with one TEG module, given a fixed amount of heat, Q (watts). The TEG module was set up and placed on a hot plate. The heat input (watts) of the hotplate was controlled through a central control unit. As shown in Table 5 above, the data collected was done so at 25 Watt intervals from a minimum of 50 Watts to a maximum of 175 Watts. To predict results with a higher heat input, the graph was extrapolated out to 300 Watts. The best fit curve was chosen to be represented by a logarithmic function since that function, through trial and error, proved to be the best representative of the expected relationship between heat and voltage output.

Graph 1 clearly shows that as heat increases, the amount of voltage output increases at a lower rate. In other words, there are diminishing returns with the TEG module as more and more heat is applied. This would make sense as there is a limited number of conductive elements within the TEG module. There will only be a certain amount of charge that will be generated from the electrically charged conductors within the TEG module once the system reaches equilibrium. The results also agree with the technical specifications of the TEG module itself. As the specifications found in the appendix show, as temperature of the lower (hot) surface increases, the voltage output starts to stabilize. This is true regardless of the temperature of the upper (cooler) surface. This shows that the system will reach an equilibrium point. After this equilibrium point is reached, applying more heat would only damage the TEG unit and not add any gains to the voltage output.

Table 6: Voltage generated per chip from six TEG modules

Heat, Q (Watts)	Voltage Output (Volts)	Voltage Output per Chip (Volts)	Temperature Lower Plate Surface (°C)	Temperature Upper Plate Surface (°C)
50	1.46	0.243333333	32.6	25.5
75	2.29	0.381666667	39.7	29.2
100	3.29	0.548333333	49	35
125	4.06	0.676666667	58.5	38.4
150	5.44	0.906666667	73	44.4
175	7	1.166666667	85	54.7

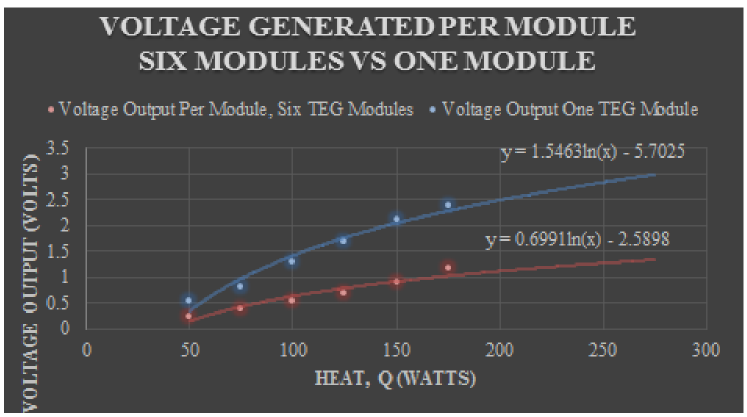
Table 6 shows the voltage output readings obtained from the unit with six TEG modules. It is the same as those found on Table 4. As with the previous experiment with one TEG module, readings were recorded at intervals of 25 Watts. The average of three separate readings was taken as the system was allowed to stabilize at each point. The readings, however, are not an overall voltage output but a per module output, so that they can be compared to the readings obtained with one TEG module.



Graph 2: Voltage generated from six TEG modules (per chip)

The data in Table 6 is plotted on Graph 2. As with the previous graph, it shows the relationship between heat input and the amount of voltage generated that was obtained during the trial with six-TEG module. As stated above, the results shown are per module; the readings obtained with the six modules were divided by six to compare with the result obtained for one TEG module. The six TEG module test unit was set up the same way as the one TEG test module unit. The data on the graph was extrapolated out to 300 watts for visualization and comparison and a best fit line was determined to show the relationship between heat and voltage.

Similar to the graph for the test unit for one-TEG module, this graph levels off as the amount of heat input increases. This is expected as the behavior for six TEG modules should follow the behavior of one TEG module; the same concepts apply. There is a limited charge that can be created on the conductive components within the TEG modules as they are heated up. Once those conductors reach a certain point, they will no longer keep charging positively or negatively due to their material properties. A sort of equilibrium is achieved between the positively charged side of the material and the negatively charged side; the conductor won't give up any more electrons or accept any more respectively. As with the previous trial with the test unit with one TEG module, a logarithmic function was chosen to represent the best fit curve.



Graph 3: Voltage generated from one chip TEG modules

When comparing the curves for the six-TEG module and the one TEG module, they both exhibit similar behavior. As discussed above, this is an expected finding. However, what is also very clear is that the voltage output from the test unit with six TEG modules was significantly lower than the voltage output for the one TEG module test unit. There are many reasons for this lower output of voltage. The first reason is that the plate was changed from the one TEG test unit to the six TEG test unit. The plate used in the former, was 0.04-inch thick, but too thin to hold the extra weight of the additional TEG modules and heat sink. The 0.004-inch-thick aluminum plate started to curve and the contact surface between the aluminum plate and the TEG modules and the hot plate was uneven. This prompted the change to a thicker 0.125-inch aluminum plate to hold the six TEG module test unit. This increase in the thickness of the plate affects the heat transfer from one side to the other.

Secondly, the hot plate appeared to be too small to adequately heat the six TEG module test unit. Readings were obtained for each TEG module individually; these showed that the modules in the center of the plate, directly above the thermal source, had higher voltage reading than the modules located at the corners.

The six-TEG unit did not seem to be transferring heat as well as the single TEG unit. This may be due to the decrease in the ratio of TEG module surface area to heat sink surface area. When the one TEG unit was tested, there was one large heat sink for transferring the heat on the top side of the unit. When the six-TEG unit was tested, an additional heat sink was added, though not of the same size. The additional heat sink was added so that all six TEG modules would be in full contact with a heat sink. Therefore, the heat sinks in the six-TEG testing unit had to transfer a greater amount of heat than the heat sink in the one TEG test unit. This factor could have also contributed to the less efficient results generated by the six TEG test unit.

5. CONCLUSION

This project showed the performance of a TEG system under a controlled heat input condition. The project showed that electrical power could be generated from a thermal source of energy, without a complicated mechanism. It demonstrated that designing an adequate system to maximize efficiency can be quite a complicated task. In this project, the power achieved was not close to the optimal working conditions of the TEG modules and therefore they were not able to generate the manufacturer specified power. Achieving these conditions in the real-world, would also be quite difficult, because temperature is something that cannot always be controlled and/or regulated. Efficiency is also an issue, because when it comes to connecting multiple TEG modules to generate more power output, the project clearly demonstrates that efficiency decreases when more units are placed together. It was also observed that there is a limit to the voltage that can be generated, because once these TEG modules reach a certain point of heat input, their power output levels off. Further testing should be done to determine whether or not the manner in which TEG modules are connected, in series or in parallel, affects efficiency. Beyond the specifications of the TEG modules themselves, there are other factors to consider such as material and thermal insulation.

Nonetheless, this project was able to utilize what would normally be wasted heat in order to power everyday devices, such as a portable battery pack. Through a simple configuration, a flame/heat source could be used to power our device. While deficiencies in the design were observed, with further research and development, these deficiencies could be overcome.

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Smart Mailbox

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ABSTRACT

Mailboxes have existed since 1653 in Paris, France and they are now found worldwide. With all the technological advances made throughout the ages, the mailbox has remained the same. Nowadays, online shopping has become a convenient way to order a favorite product without the hassle of leaving the house. However, the ordered products can be lost even though the merchandise has been sent to the customer. Millions of letters and packages are missing each year or stolen directly from the front of the owners' home. This could be due to their mailbox being left open, since a package is too big to fit inside. The project is to design and build a mailbox that can extend to fit larger sizes of mail packages, also notifying the owner when mail has arrived and keeping it safe until the owner collects it. The mailbox is user-friendly, easy to operate, and inexpensive. This report will detail the steps and process in the design and implementation of a mailbox system.

Keywords: mailbox, microcontroller, wireless, extension and locking mechanisms

1. INTRODUCTION

Over 100 billion letters and packages are mailed each year around the world but not all reach their destinations. Even the ones that do reach their destinations are not always acquired by the owners. A tremendous amount of mail goes missing or is stolen, right in front of peoples' homes. This creates a need for a mailbox that can hold letters and packages and keep them secure until they are retrieved. If a person owns a large property, then chances are the house may be far from the gate and the mailbox. Therefore, a mail notification system would prove most useful to such residents.

The objective of this project is to create a smart mailbox that will inform the owner when a piece of mail has arrived via a message sent through wireless communication. Furthermore, the mailbox should expand to accommodate larger size packages and securely keep them in place until they are collected. It will be user friendly and simple to operate. The device consists of a keypad with a security code needed in order to remove any of its contents.

Traditional mailboxes only hold letters and small packages. In the 21st century, a lot of shopping is done online with straight-to-door delivery. Most of these articles would not fit in a traditional mailbox. There are parcel drop-boxes or delivery vaults which can accommodate larger packages; however, these are big, heavy and expensive. There is no mailbox available on the market that adjusts its size to hold larger packages. A prototype mailbox was created called “Mr. Postman” which sends a notification on a user’s phone via Wi-Fi [1] when mail arrives. The box can be locked and unlocked via the phone, and it can also be unlocked by the person’s neighbor if a onetime passcode is sent. This device does not have a key or keypad to open. Therefore, if the phone stops working, another device may be needed to operate it. Moreover, it has only one-size and is not be suitable for larger packages.

There are certain devices such as Mail Chime, which could be purchased and installed on a mailbox; these flash a blue LED light whenever the mailbox is open [2]. This requires the owner to be home and next to the receiving device to see the flashing notification light, and it can cost anywhere from $40 to over $100 and doesn’t protect the mail. Mail Chime, for example, only has a range of 300 feet in ideal conditions, and if the user is not home and next to the receiver, he or she will not know whether mail has arrived. Another device called Smarthome Select has similar functionality as the mail chime. It sends a wireless communication signal up to 300 feet away alerting both audibly and visually when the mailbox is open. Both these devices only alert when the mailbox is open or closed, but they do not actually notify the owner if any mail arrives, and they do not alert the owner if anyone is tampering with the mailbox.

There is currently only one “smart mailbox” called uCella which costs $299 [3]. It scans the Quick Response (QR) code from a tracking number and opens the mailbox with that or the owner’s master code. Whenever the code is scanned, it alerts the owner if a package has been delivered. The mail carrier needs to know the code in order to open this mailbox, and he or she has to scan the correct tracking number based on the owner’s email address or it will not open. Once the mailbox is unlocked, the mailman would have to manually release the extension part of the mailbox downwards, then place the package inside and close it by pulling the cover up to secure the mails. If the package delivered tracking number is not on one of the synced email for uCella or is not manually entered by the owner, uCella will not open.

Figure1: uCella Mailbox Closed

Figure2: uCella Mailbox Extended

Based on the background research, we plan on designing and building a mailbox that incorporates ideas from existing ones to provide an alternative, less-expensive model. It will have the wireless notification capability of the Mr. Postman and uCella without the limited range of other devices such as smart home and mail chime. It will be able to notify when mail has been placed inside the mailbox instead of just sending a signal saying the mailbox is open or closed, because that does not actually inform the owner if mail is placed inside. It will also be able to extend to hold larger packages while keeping them secure. Unlike any of the previous mailboxes, this system will include a door that can automatically close if it is left open by the user. It will be lighter and smaller than uCella which is 18 lbs and over 40 inches high when opened.

2. HARDWARE DESIGN

Front Door ("L Shape")

A significant problem encountered was a design for the front door, where people would be able to put mail into the mailbox without anyone else being able to take the contents out without the key code. An "L" shaped design was chosen (as shown in Figure 3) that, when the door is open, has the bottom portion of the L come up and block anyone from reaching in. When the door is closed, that part goes down and the mail is free to move further into the mailbox and be secured. This was the only practical solution found, but there is one set back to this design, which is the size of the mail that goes in will now be limited to dimensions of 10x10x10 in^3. The package going in cannot be longer than 10 inches because of the height of the door.

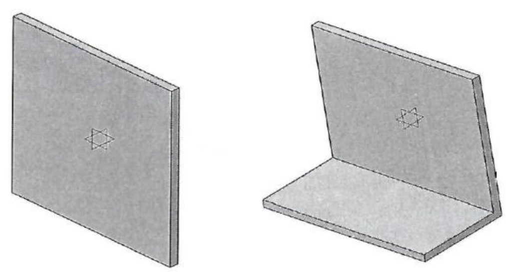

Figure 3: Back Door & L Shape

CAD

The design for the mailbox was made on CATIA. It is comprised of five different components which when they are assembled, form the mailbox. These components are an inner section that holds the front door, an outer section that holds the back door, as well as a letter slot with a backdoor and front door. The inner and outer section would have dimensions of 13x10.5x12.5 in^3 and 13x11x14 in^3, respectively. The back door would be 10.5x.5x12.5 in^3. The L shaped front door is comprised of two sections which are 5x10x.5 and .5x10x10 in^3, respectively. And finally, the letter slot is .5x10x1.75 in^3.

After the CATIA models were made, testing was done to see if it would be possible to print using the current dimensions. The largest 3D printer at Vaughn was not capable of 3D printing the inner and outer section of the mailbox. An attempt was made to lower the dimensions to 80% of the current size and after a long process of computation on the PC, it was determined that only one of those two sections at 80% of the current size would take three days to print. That means it would take 6 days of back to back printing nonstop to get the inner and outer sections printed. We would also need to get more 3D printers to print the other three remaining parts. This procedure would take hours upon hours to clear the inside support materials if it was printed.

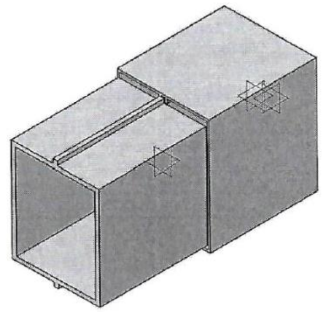

Figure 4: Mailbox Extension (Inner & Outer Section)

Alternate Design-Wood

After realizing the time it would take to 3D print the mailbox, it was decided to just manually build the mailbox using wood. The material used was approximately ¼ inch thick plywood from Home Depot and the various sections of the mailbox were cut out according to the CAD model that was made. Each of the components was cut out and needs to have epoxy applied to build the mailbox structure. This process was a lot shorter and took a few hours, rather than waiting an entire week to get a print.

Calculations

The hinge design is used in the project to support the door. The dimension of lower plate of the door's length is 12x10x0.5 in^3. The dimension of the upper plate of door's length is 12x5x0.5 in^3. The life of the hinge rod can reach up to 15,234 cycles. The length of the hinge rod is 9.25 inches with the diameter of at least 0.242 inch. The hinge rod is made of hot-rolled steel AISI 1020 with ultimate tensile strength of 55,000 psi. The surface finish of the hinge is hot-rolled surface with expected reliability of 95%. The safety factor of 2 is used and there is no stress concentration. The designed load of 10 lbs. is uniformly distributed on a simply supported hinge rod with the bending stress of 8,282.74 psi. The endurance limit stress of the hinge rod in reversed bending stress is 27,500 psi with the corrected endurance limit of the hinge is 541.85 psi, and the endurance limit of permissible stress amplitude in reversed bending is 433.48 psi.

To calculate the diameter of the hinge rod and also the life cycle, the following calculation is conducted. Firstly, the symbols are defined in Table 1. In Table 1, we have the symbols in the following meaning. Table#2 represents surface finish factor, Figure#3 represents the surface finish factor graphs and Figure#5 for the construction of S-N fatigue life curve of steel.

In Table #1, S_{ut} is ultimate tensile stress (psi); k_b is size factor; k_c is reliability factor; k_d is modifying

Table 1: Mathematical Formulation

Expression	Name	Units	Equation No.
$S_e^{'} = 0.5S_{ut}$	Endurance limit stress	psi	1
$S_e = k_a k_b k_c k_d S'_e$	Corrected endurance limit stress in torsion	psi	2
k_a=a*(S_{ut})^b	Surface finished factor		3
$(S_e)_a$=0.8(S_e)	Permissible stress amplitude	psi	4
$\sigma_a = (S_e)_a / FS$	Amplitude stress in the hinge rod for finite life	psi	5
$\sigma = P_a / A$	Normal stress	psi	6
$\sigma_b = Mc / I$	Bending stress	psi	7
M= $wl^2 / 8$	Bending moment	lbs-in	8
$I = \pi d^4 / 64$	Moment of inertia	in^4	9
$\delta = PL / AE$	Deflection	in	11

factor to account for stress concentration; S'_e is the endurance limit stress of rotating beam specimen subjected to reversed bending stress (psi); FS is the factor safety; P_a is the reversed axial load (lbs); A is the area of the hinge (in^2); the moment of inertia I is taken about the horizontal axis through the centroid (in^4); c is the distance to the material point furthest from the neutral axis (in); w is uniformly distributed load (lbs/in); l is the length of the hinge rod (in); α is the coefficient of thermal expansion and Δt is the change in temperature (°F). For the parameters in Table#1, Table#2, Tables#3, Table#4 and Figure 5 describe the ranges of them.

Table 2: Surface Finish Factor

Surface finish	a	b
Ground	1.58	-0.085
Machined or cold-drawn	4.51	-0.265
Hot-rolled	57.7	-0.718
As forged	272	-0.995

Table 3: Size Factor

Diameter (d) (mm)	K_b
d$\leq$7.5	1.00
7.5<d$\leq$50	0.85
d>50	0.75

Table 4: Values for Reliability Factor

Reliability R (%)	K_c
50	1.0
90	0.897
95	0.868
99	0.814
99.9	0.753
99.99	0.702
99.999	0.659

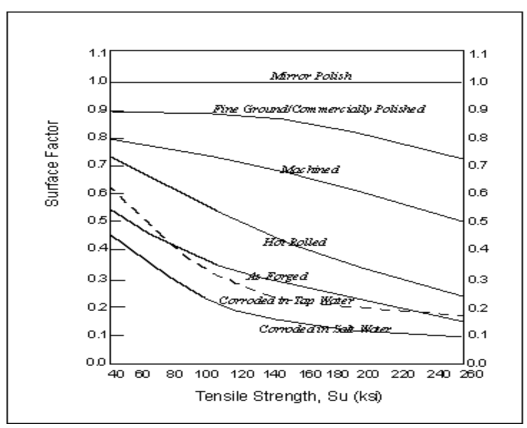

Figure 5: Surface Finish Factor Graph

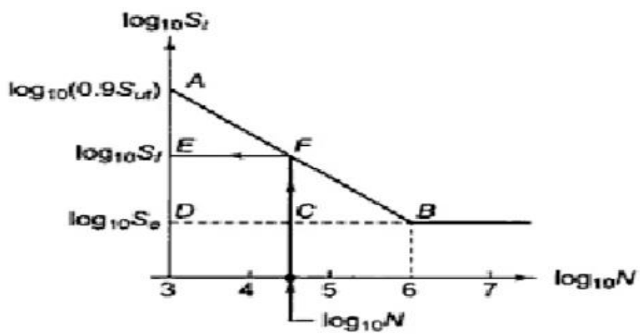

Figure 6: Fatigue Life S-N Curve for Steel

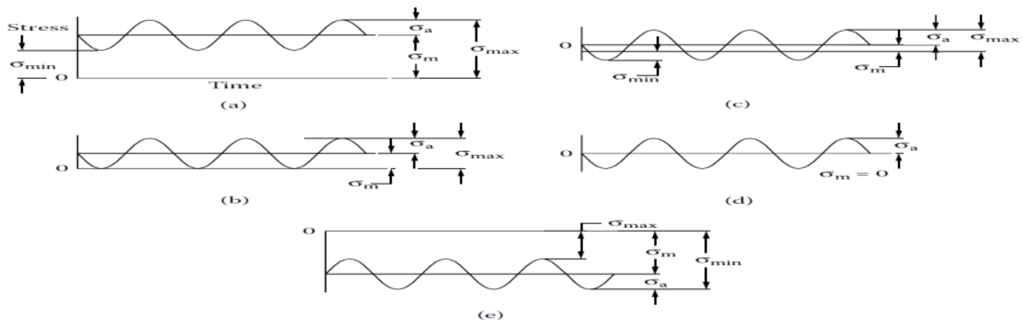

Figure 7: Types of Cyclic Stress

To calculate the endurance limit stress using Equation#1 (Table#1), the following process holds,

Given: S_{ut} =55,000 psi. Solution: $S_e^{'} = 0.5S_{ut}$ =0.5x55,000 =**27,500 (psi)**

To calculate the corrected endurance limit stress for hot rolled steel with 95% reliability factor using Equation#2 of Table#1. To find the corrected endurance limit, the first step is to find the surface finish factor and then the size factor. The last step is to find the reliability factor. Since there is no stress concentration factor, the step is skipped. The following steps are the calculation of corrected endurance limit stress:

Step 1. Find the surface factor of hot rolled steel using Equation#3 of Table#1 and Table#2 for a and b values,
Given: S_{ut}=55,000 psi. Solution: k_a =ax(S_{ut})^b = (57.7) (55,000)$^{-0.718}$, k_a =0.0227.

Step 2. Find size factor using Table#3,
Assume d<7.5 mm, the size factor is k_b =1.

Step 3. Using Table#4 for 95%, the reliability factor is k_c =0.868. Then, the corrected endurance limit for the rod using Equation#2 of Table#1 is as follows,
Given: k_a =0.0227; k_b =1; k_c =0.868.

Solution: $S_e = k_a k_b k_c S'_e$ $= (0.0227)(1)(0.868)(27{,}500$. $S_e = 541.85$ (psi).

To find the endurance limit of permissible stress amplitude in reverse bending for axial loading using Equation#4 of Table#1:

Given: $S_e = 543.81$ psi. Solution: $(S_e)_a$ =0.8(S_e) =0.8(543.81). $(S_e)_a$ **=** 433.48 psi.

To find the amplitude stress in the hinge rod use Equation#5 of Table#1:

Given: $(S_e)_a$ =4353.48 psi and FS= 2. Solution: $\sigma_a = \frac{(S_e)_a}{FS} = \frac{435.048}{2}$, σ_a =216.74 psi

The design diameter of the hinges rod under reverse stresses holding a load for a finite cycle is: Using Equation#6 of Table #1, it can be found that σ =*P*/*A*.

Given: σ_a =216.74 psi and P =10 lbs. Solution: $\frac{\pi d^2}{4} = \frac{10}{217.52}$, **d=0.242in.**

To find the life of the hinges rod for a reliability of 95% by constructing the S-N curve for the hinges from Figure#5. The hinges rod made of steel is designed for finite life; the S-N curve is only valid for steel.

Step 1: 0.9 S_{ut} =0.9(55,000) =49500psi.

Step 2: $\log_{10}(0.9\,S_{ut}) = \log_{10}(49{,}500)$ =4.6946

Step 3: $\log_{10}(S_e) = \log_{10}(541.85)$ =2.73

Step 4: $\log_{10}(S_f)$ where $S_f = \sigma_b$ = bending stress.

To get the bending stress of a simple supported hinge with uniformly distributed load. Using Equation#7 of Table #1, it is found that $\sigma_b = Mc/I$.

Given: *w*=1.63 lbs/in and l=9.25inches.

Step 4.1. Find the bending moment using Equation #8 of Table #1.
Given: w=1.08 lbs/in and l=9.25inches.
Solution: M= $wl^2/8 = (10/9.25)(9.25)^2/8$ =11.56in.

Step 4.2. Find the Moment of Inertia, use Equation#9 of Table#1.
Given: d= 0.242in. Solution: $I = \pi d^4/64$ => $I = \pi 0.242^4/64$ =168x10^{-6} in^4 .

Step 4.3. Find c:
Given: d= 0.242 in. Solution: $c = d/2$ $= 0.242/2$. c = 0.121 in.

For bending stress using Equation 7 of Table#1:
Given: c = 0.121 in, I =168x10^{-6} in^4 and M= 11.56in,
Solution: $\sigma_b = Mc/I$ => $\sigma_b = 11.5 \times 0.121/0.000168$ = 8282.74(psi)
Since $\sigma_b = S_f$ **,** we have $\log_{10}(S_f) = \log_{10}(8282.74)$ =3.92

Step 5: $\log_{10}(10^3) = 3$

Step 6: $\log_{10}(10^6) = 6$

Step 7: From Figure 5 for constructing S-N curve to calculate for fatigue life.
The fatigue life of hinge rod is: $\bar{EF}/\bar{DB} = \bar{AE}/\bar{AD}$.

where $\bar{EF} = \dfrac{(6-3)(4.6946-3.92)}{(4.6946-2.73)}$ =1.18 and $\log_{10} N = 3 + \bar{EF}$ =3+1.18 =4.18

Therefore, N=$10^{4.18}$ => **N=15,234 cycles.**

3. SOFTWARE DESIGN

There are currently two software systems implemented into the project. The first one is used to detect mail using an infrared sensor. After the Arduino micro-controller board detects a mail in the box, a signal will be sent to the Wemos D1R2 WIFI board. This board is connected to the internet via a wireless router at home. After the Wemos receives the signal from the Arduino board it will send a connection request to the online Carriots server and then send a data stream saying that a mail has been received. Carriots has two listeners associated with the mail sensor device. These listeners will wait until the server receives the data stream and will send an email and a text message to the user.

The second system is designed to control the locking mechanism as well as the keypad to read a passcode entry. As soon as the Arduino board is turned on, the electromagnet locker will activate and lock the mailbox. The Arduino board will detect the input of the keypad. The passcode library for the Arduino board is used to determine whether the entered code matches the accepted code. If the entered code is incorrect, a red LED will blink once. If a second entry code is still incorrect, the LED will blink twice. Finally if a third wrong passcode is entered the LED will blink three times and an alarm will sound and no more passcodes will be allowed for a period of time. Should the correct passcode be entered any of the three times, a green LED will turn on and the electromagnet will shut off, which allows the mailbox door to open. After a certain amount of time the LED will shut off and the electromagnet will turn back on, and the door will lock when it is closed. The Arduino board with keypad and alarm circuit is shown in Figure 8 and Figure 9, respectively.

Figure 8: Locking System

Figure 9: WIFI Board with IR Sensor

Tables 5 and 6 display the programs used to run the locking system and WIFI communication.

Table 5: Passcode for Locking System

```
#include <Password.h>
#include <Keypad.h>
Password password = Password( "0000" ); //password to unlock, can be changed
int count=0;
const int buzzer = 11;
const byte ROWS = 4; // Four rows
const byte COLS = 4; // columns
char keys[ROWS][COLS] = {{'1','2','3'}, {'4','5','6'}, {'7','8','9'}, {'*','0','#'}}; // Define the Keymap
byte rowPins[ROWS] = { 6, 7, 8, 9 }; // Connect keypad ROW0, ROW1, ROW2 and ROW3
byte colPins[COLS] = { 3, 4, 5 }; // Connect keypad COL0, COL1 and COL2
Keypad keypad = Keypad( makeKeymap(keys), rowPins, colPins, ROWS, COLS ); // Create the Keypad
void setup(){
 Serial.begin(9600);
 Serial.write(254);
 Serial.write(0x01);
 delay(200);
 pinMode(2, OUTPUT);   //green light
 pinMode(buzzer, OUTPUT);  //alarm
 pinMode(12, OUTPUT);  //red light
 pinMode(13, OUTPUT);  //lock
 keypad.addEventListener(keypadEvent); }
//add an event listener for this keypad
void loop(){
 keypad.getKey();
 digitalWrite(13, HIGH); }
 void keypadEvent(KeypadEvent eKey){
 switch (keypad.getState()){
 case PRESSED:
 Serial.print("Enter:");
 Serial.println(eKey);
 delay(10);
 Serial.write(254);
 switch (eKey){
  case '*': checkPassword(); delay(1); break;
  case '#': password.reset(); delay(1); break;
  default: password.append(eKey); delay(1);}}}
void checkPassword(){
  if (password.evaluate()){
     //if password is right open
    Serial.println("Accepted");
    Serial.write(254);delay(10);
   //Add code to run if it works
    digitalWrite(13,LOW);
    digitalWrite(2,HIGH);
   delay(5000);
   digitalWrite(13,HIGH);
   digitalWrite(2,LOW);
   password.reset();}
else{
   count=count+1;
   if (count==1){
     Serial.println("Denied attempt1");
     digitalWrite(12, HIGH); //turn on
     delay(2500); //wait 2.5 seconds
     digitalWrite(12, LOW);//turn off
     password.reset(); }
   if (count==2){
     Serial.println("Denied attempt2");
     digitalWrite(12, HIGH); //turn on
    delay(2500); //wait 2.5 seconds
    digitalWrite(12, LOW);//turn off
    delay(2500);
    digitalWrite(12, HIGH); //turn on
    delay(2500); //wait 2.5 seconds
    digitalWrite(12, LOW);//turn off
    password.reset();}
   if (count==3){
    Serial.println("Denied attempt3");
//if password's wrong keep locked
    Serial.write(254);delay(10);
    tone(buzzer, 500); // Send 1KHz sound signal
    digitalWrite(12, HIGH); //turn on
    delay(2500); //wait 2.5 seconds
    digitalWrite(12, LOW);//turn off
    delay(2500);
    digitalWrite(12, HIGH); //turn on
    delay(2500); //wait 2.5 seconds
    digitalWrite(12, LOW);//turn off
    digitalWrite(12, HIGH); //turn on
    delay(2500); //wait 2.5 seconds
    digitalWrite(12, LOW);//turn off
    noTone(buzzer);     }}}// Stop sound...
```

Table 6: Code for WIFI Communication

```
#include <ESP8266WiFi.h>
const int ON = 1;    // Constant to indicate that there is mail
const int OFF = 2;  // Constant to indicate that there is no mail
const String APIKEY = "6ed3803c2240c2bb71001121c81dbf9b24df56b3495828f889088046307eacac";
//Replace with your Carriots apikey
const String DEVICE ="MailSensor@spiderpook.spiderpook"; //Replace with the id_developer of your device
const char* ssid = "vaughncollege"; // WIFI SSID
const char* password = "abcdef0987654321abcdef0987"; // WIFI Password
IPAddress server1(82, 223, 244, 60); // api.carriots.com IP Address
WiFiServer server(80);
WiFiClient client = server.available();
int sensorPin = 0;
int ledPin = 14;
int mail = LOW;
void setup() {
pinMode(ledPin, OUTPUT);
pinMode(sensorPin, INPUT);
Serial.begin(115200);
delay(10);
// Connect to WiFi network
Serial.println();
Serial.println();
Serial.print("Connecting to ");
Serial.println(ssid);
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");}
Serial.println("");
Serial.println("WiFi connected");}
void loop() {
   if (digitalRead(sensorPin) == HIGH) {
   mail = HIGH;
   digitalWrite(ledPin, HIGH);
   sendStream(); }
  delay(500);
  while (client.available()) {
   char c = client.read();
   Serial.print(c);}
  if (!client.connected()) {
   client.stop();  }}
 // Send stream to Carriots
 void sendStream(){
   String txt = "";    // Text to send
   if ( mail == LOW ) { txt = "OFF";} // Alarm OFF
  else { txt = "ON";}// Alarm ON
  Serial.println(txt);      // For debugging purpose only
   if (client.connect(server1, 80)) {
  // If there's a successful connection
     Serial.println(F("connected"));  // Build the data field
 String json="{\"protocol\":\"v2\",\"device\":\""+DEVICE"\",\"at\":1356390000,\"data\":{\"Mail\":\""+txt+"\"}}";
  // Continual program
  // Make a HTTP request
     client.println("POST /streams HTTP/1.1");
     client.println("Host: api.carriots.com");
     client.println("Accept: application/json");
     client.println("User-Agent: Arduino-Carriots");
     client.println("Content-Type:
application/json");
     client.print("carriots.apikey: ");
     client.println(APIKEY);
     client.print("Content-Length: ");
     int thisLength = json.length();
     client.println(thisLength);
     client.println("Connection: close");
     client.println();
     client.println(json); }
  else { // If you didnt get a connection to the
server:
    Serial.println(F("connection failed"));}}
```

4. Conclusion

The mail industry continuously grows as the world's population increases. There is an increased need for a technologically-advanced, economical mailbox that will not only make lives easier for users but also provide security. The mailbox developed in this project will appeal to many due to its multiple functions and low cost. With this mailbox, no one has to brave the elements to look into and then find nothing inside their box, and this mailbox alerts an owner when he or she receives mail. When residents need to be away from their home for extended periods of time, this mailbox can accommodate more mail while keeping these articles secure. This is the mailbox of the future.

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Authorization & Disclaimer

Variable Pressure Cast

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ABSTRACT

Casts have been part of human history since ancient times. They first began as splints made from two pieces of tree bark wrapped with linen in order to keep injured limbs from moving and healing correctly. Over the centuries, bonesetter doctors discovered many methods for healing fractured or broken limbs, such as modifying the way casts are used present day. The most commonly used substance in cast production is plaster or fiberglass. Whatever the material, all casts serve the same function of keeping broken or injured bones from moving until the body part properly heals. Casts also support the muscles of injured limbs to help reduce pain and swelling. When one is injured, flexing muscles can produce an increase in pain and swelling, and casts are a useful device to prevent the movement of muscles. The problem with the most common cast materials, such as plaster or fiberglass, is that they deny the patient access to the body part beneath the cast. The cast cannot be temporarily removed without access to reapplication by a medical professional. Therefore, a new method of cast design is necessary and forms the focus of this paper.

1. INTRODUCTION

An orthopedic cast is a shell or outer casing, often for a limb, which is intended to hold a broken bone in place while it heals. Orthopedic casts date back to the times of The Ancient Egyptians. A bark tree splint tightly wrapped in linens is the earliest known method for treating bone fractures. Egyptians used their embalming techniques to construct a tight set of splints around the affected area. Centuries passed but the casting techniques barely changed, even though newer materials found to be more useful have become available. After a bone has been diagnosed as broken and properly reset, a cast is formed around the fractured bone to protect it and allow it to heal. Broken bones are extremely common injuries; an average of 6 million people in the United States will break a bone each year. Most of these broken bones heal without long term problems. However, about 300,000 are slow to heal or do not heal at all. The most common material used in a cast is plaster, as shown in Figure 1. This is the most common material used in cast production, with cotton placed on the inside of the cast for comfort. [1]

Figure 1: Plaster Cast

The advantages of these casts are that they do their job very well and keep the bones still and in place while they heal. They also protect the injury from minor mishaps, such as moving too much or hitting the injured body part, thus causing extreme pain. The disadvantage of this cast is that once it is placed one no longer has access to the affected body part. Doctors use a medical saw to remove the cast (Figure 3). This procedure should only be attempted by doctors since it may cause injury to the patient. Once the cast is off, there is no way to replace it unless one returns to the doctor for a re-cast, a time-consuming and expensive procedure. A further problem with the cast is that the human body continually casts off its old skin cells. While under a cast, an arm or leg has nowhere to dispel dead skin cells accumulating in the cast, leaving skin dry, scaly, dirty, and odorific. Furthermore, no contact with water is permitted with these casts or the cast will fall apart leaving the fractured part vulnerable to healing incorrectly. Fiberglass casting, on the other hand, is waterproof, even though the inside padding is not. If water gets inside the fiberglass, the cast needs to be replaced because there is no opening or closing on the cast. [2]

Figure 2: None-Waterproof Cast

Figure 3: Medical Saw [3]

Clearly the need exists for an improved and economical cast and new technologies exist to provide one.

2. OBJECTIVE

The objective of this project is to redesign a cast that will do its job correctly while allowing patients to:

- Shower without the need to protect their cast from getting wet and ruined.
- Allow ventilation of the injury in order to keep dead skin cells from accumulating within the cast, with the added benefit of reducing or eliminating odor.

- Allow patients to adjust the pressure of the cast for comfort while the cast's purpose of maintaining stability and protection remains unaffected.

3. APPLICATION

3D printing is a revolutionary gateway to a simpler life. With 3D printing we can bring to life almost anything that can be imagined. Through innovation and time we can replace just about anything with the right material and a 3D printer. Even a 3D printed cast costs very little, with the exception of the cost of the printer. There are many kinds of printers to choose from within a variety of price ranges and which utilize all kinds of filaments.

People worldwide will benefit from this new cast since it can be printed on the spot for anyone in need. This new form of cast is not adversely affected by water and it can be left open for much-needed ventilation of the affected body part. In parts of the world where rain is a common occurrence, this new type of cast will also no longer lose its shape or deteriorate.

4. TECHNICAL APPROACH

An orthopedic, body, or surgical cast is a shell, frequently made from plaster or fiberglass, encasing a limb or in some cases, large portions of the body to stabilize and hold anatomical structures, most often a broken bone, in place until healing is confirmed; then it is removed. The cost for broken bones is expensive and can be in the $10,000 range without insurance; even with insurance this procedure can be very expensive. The necessity for a new-model cast is apparent.

As of now, we have three design concepts. The first concept is that of an open-design cast that allows air to flow freely within the cast, while screws on the inside can be adjusted for pressure and comfort. The second concept additionally includes a pressure cushion/blood pressure cuff in the inside of the cast to allow for maximum hold to the area depending on the patient's injuries. The third concept consists of the same outside design, however, the inside will be adjustable, using Velcro straps. All these design concepts are meant for the full life of a cast from the beginning of the injury until the moment the person is healed enough for cast removal. Some casts have two phases. One cast is used until the injury is somewhat healed; then a splint is used until full recovery of the fracture.

The first design was chosen as the best option employing our current knowledge, and it employs holes with screws on the side that push upon the inner cast to apply pressure and make adjustments for comfort. The tools needed to produce this product are a 3D printer, filaments, patient measurements for the cast, CAD software, and Finite element software. The step by step process is presented below.

Among multiple design choices, the (Figure 4) design was chosen for its simplicity and the fact that it has many exposed areas for ventilation.

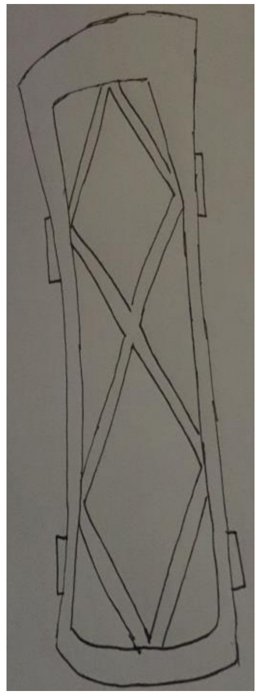

Figure 4: Initial sketch of the cast

The Second step was to bring to life the drawings by using one of the group member's arms and an Artic Scanner (Figure 5) to create a 3D representation of a cast on 3DS Max. The overall body shape of the cast was fitted to the arm as seen in (Figure 5). With this step completed, the cast was converted into nurbs and then converted into polygons so the file could be converted to an *.obj* file as shown in (Figure 6). One more step is required for the file to be transported into CATIA in order to perform the final edits to the cast.

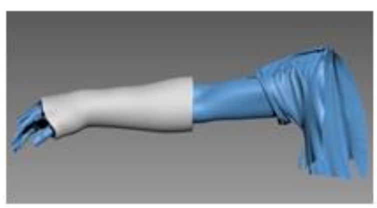

Figure 5: Arm/Cast in 3DSMax

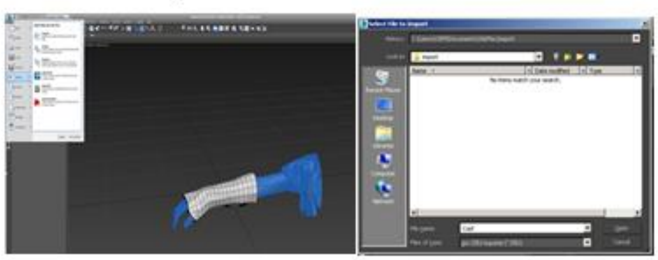

Figure 6: Process behind converting the 3DS Max Files into a .obj

The Artic 3D Scanner captures small objects or intricate details of a large industrial object in high resolution with steadfast accuracy. It can render complex geometry, sharp edges and thin ribs. Using the artic scanner, an arm can be rendered through 3d software such as 3DS Max. Using the arm as a basic shape, the cast is modelled and modified to a reasonable size allowing space for the inner cast in which the pressure adjuster will be set. The 3DS Max Files are thus converted into an *.obj* file to proceed with the project. Then the file is brought into Maya to be converted into CATIA.

The Third step is to use the CATIA file to shape out the design sketch that was shown in (Fig. 7).

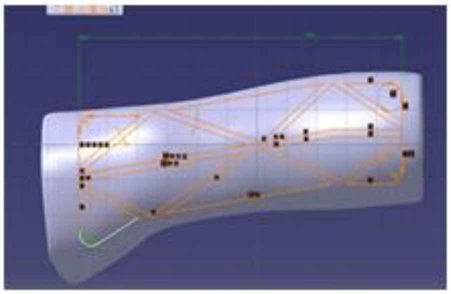

Figure 7: Cast Modification in CATIA

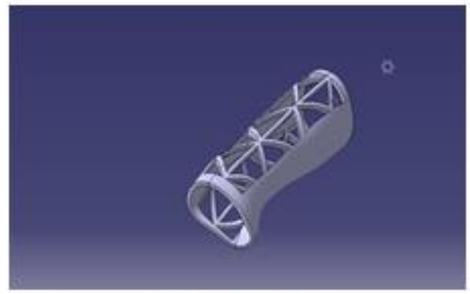

Figure 8: Sketch brought to life

Figure 8 shows the involvement of the sketcher feature in CATIA while Figures 9 and 10 show what it looks like afterwards.

The Fourth step is to use the 3D representation in the second design to create the inner cast and import it into CATIA, then to cut off some of it to allow air exposure from the top.

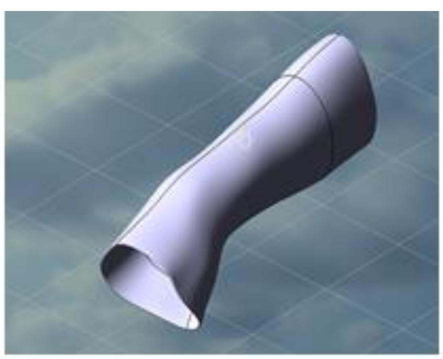

Figure 9: Inner cast

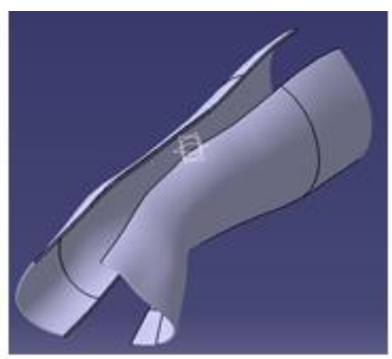

Figure 10: Inner Cast cut into two

The Fifth step was to use the Maker Bot 3D Printer to print out the cast. The Maker Bot Application must be opened on a computer and then exported into a file which the Maker bot can read. The flash drive is then placed directly into the Maker Bot so there is less chance of the print failing. PLA Plastic was used for the material, because it is waterproof and durable.

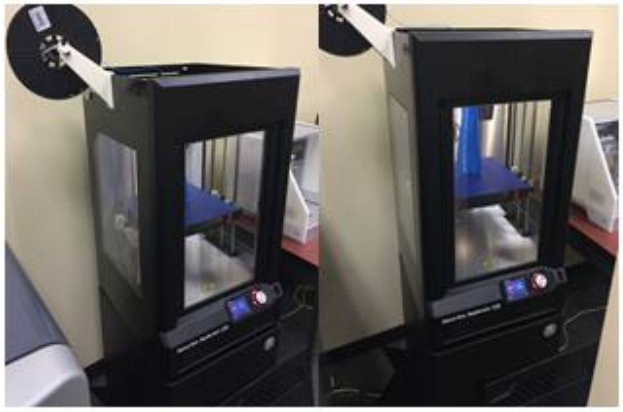

Figure 11: Maker Bot

(Figure 11) is the Maker Bot in the middle of one of our prints. It is half of the inner cast which took about 4 $\frac{1}{2}$ hours to print, while each side of the outer cast took approximately 9 hours. In total there is 27 hours of printing.

The Sixth step is to take the printed part and to complete some finishing touches on it, since it was printed in a low resolution leaving grooves behind. The cast thus needed to be sanded down, joint compound was then applied and allowed to dry, and it was sanded down again and finally painted. All of these steps can be seen in in Figure 12.

Figure 12: Preparation of Cast

The Seventh step was to add the Firm Foam Padding and 1 -1/4in screws into the inner and outer cast while also assembling the entire cast observed in Figure 13. The final product is shown in Figure 14.

Figure 13: Cast padding and screws

Figure 14: finished prototype

5. COST ANALYSIS

In total, a little more than $90 was spent on materials, and the materials listed above work the best in the following combination:

Table 1: Cost

Item	Supplier	Quantity	Unit Price	Total
EverBilt Round headed Machine Screws #6-32 x 1-1/4in	Home Depot	4	$5.00	$5.00
1/4inx1-1/2 Hex Bolt	Home Depot	4	$0.68	$3.00
1/4inx20mm Insert Nut	Home Depot	4	-	$3.00
Lock Nut Nylon Lock	Home Depot	4	-	$1.18
Universal Spray Paint	Home Depot	2	$7.00	$14.00
Firm Foam Padding	Patterson Medical	1	$50.00	$50.00
Shelf End Caps	Home Depot	1	$2.00	$2.00

6. DISCUSSION

Conducting a simple finite element analysis using CATIA showed the highest stress was where the screw made contact with the cast. It is 81 MPa while the highest stress *PLA* can withstand is 50-60 MPa. Therefore the material would fail. The reason why the stress is so high is because the point of contact the screw is touching in the inner cast is not a flat surface and does not have any padding to relieve the pressure. Also, the highest stress was on only one side of the cast. The evidence was that 3 of the 4 screws were safe while the back-right side could fail. They all went through the same amount of stress and constraint conditions, which leads to the speculation that the shape of the cast could be a factor. The shape of the cast with screws failing to make full contact with the cast leads to the high stress. Furthermore, in the real life equivalent of the cast there are stoppers present at the end of each screw, distributing the load over a larger area and thus creating a lower stress.

7. CONCLUSION

Future work to correct this project involves adding a flat surface onto the point of contact of the inner cast in order to give the screw the full contact it requires for the 10N force to be more disperse. The outside of the inner cast should perhaps be padded. The mesh size in which we did the computation was still large; if we were to decrease the mesh more, the stress would be more accurate and much lower. The computation takes a long period of time so we kept the mesh size at a reasonable size (neither too large nor too small).

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Decentralized Multi-Robot System

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Abstract

The project outlines an idea of controlling four omni-drive robots in a specific orientation and manner with little user input or a centralized system. The robots will be able to move in a specific shape or pattern while communicating with one another using eight onboard ultrasonic sensors. The project will use ad-hoc communication through the Robot Operating System (ROS) running on Linux Ubuntu to communicate among themselves. The ultrasonic sonar sensors will allow the robot to detect the distance between itself and the neighboring robots as well as to perform obstacle detection and avoidance. The microprocessor chosen for this project is the PineA64 due to its excellent features and capabilities. Furthermore, the implemented omni-drive robot can move (or turn) more efficiently and agilely.

1. Introduction

The traditional multi-robot system consists of the robots relaying information to a centralized computer. The modern approach to establish de-centralized robotic systems is based on autonomously designated tasks. Creating a decentralized system allows the robots to handle different duties independently for industrial applications. The objective of this project is to develop four robots that will communicate among themselves using two forms of communication. The first method of communication is through the microprocessors on the robots. The purpose of this is to eliminate the necessity for a centralized processing unit. The second method of communication is using the sensors that are placed in appropriate locations that allow the robot to detect its neighbors. Swarm robotics, or multiple robots communicating with each other is on the cusp of the newest developments in robotics. Researchers from Harvard University implemented a thousand- robot system that can form shapes based on a user uploaded image [1]. However, based on the simple nature of their design, the "kilobots" used in the project cannot perform more complicated tasks.

2. Methodology

2.1 Market Requirements

1. **Durability:** With their use in factories, warehouses, and classes, the robots must be able to withstand long term test and use.
2. **Safe:** The robots must not only be able to detect neighbor robots, but also to detect any obstacles in the path.
3. **Low-Cost:** The cost of each individual robot should be relatively low, thus allowing for the expansion of robot use.

4. **Architecture:** The program architecture should remain easy to understand as well as simple to implement in the future.

2.2 General Requirements and Specifications

1. **Robot**
   a. Three wheel omni-drive chassis.
   b. Overall shape of the robot must remain circular for sonar implementation.
   c. Internal design of the robot should maximize the limited space.
   d. The robots will have ultrasonic sensors for range and obstacle detection.
   e. The stepper motors should provide enough torque to move the robot.

2. **Program**
   a. The overall architecture of the program should be neat and easy to understand.
   b. All robot commands should be organized into functions and classes.
   c. Each of the robots should have a simple one line address, for example, Groundbot_101.
   d. The programs will utilize the Robot Operating System platform on Linux Ubuntu.

3. **Communication**
   a. The communication between the robots will be done using Ad-Hoc communication with Wi-Fi networking protocol.
   b. The communication delay between any two robots should remain less than one second.

2.3 Selecting Design Concepts

The design concept of the ground robots will focus mainly on agility and efficiency. The three wheel omni-drive will allow for each of the robots to not only move forward and backward, but also strafe left and right (see Figure 1 for details). The body of each robot follows a circular design to maximize the detection range of the ultrasonic sensors and allows for the robot to detect nearby objects in 360 degrees. Furthermore, the chosen microprocessor requires a larger chassis design to fit the processor and battery. However, the robot will also have to remain relatively light-weight to prevent motor stall and to decrease power consumption from the motors. Lastly, the robot will have a low center of gravity in order to promote its agility.

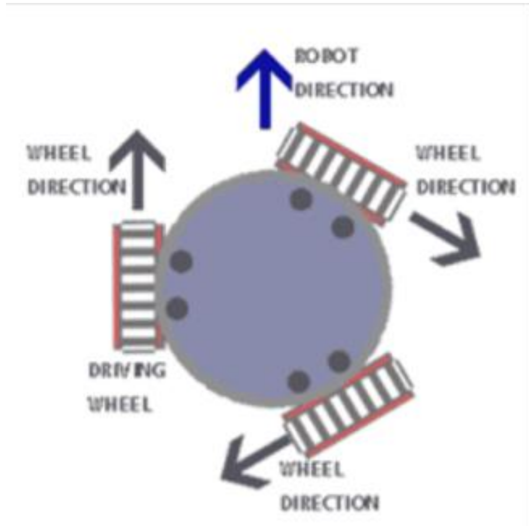


Figure 1: Three Wheel Omni Robots [2]

The robot was built using Polylactic Acid (PLA) on the Makerbot 5th Generation 3D printers. Due to the size constraint of the printer bed, the robot base was designed to be printed in three separate pieces that can be assembled into one piece, as shown in Figure 2. The pieces were created with overlapping segments to create a connection point. The general design of the robot chassis consists of a hexagonal design with slots to fit each of the three stepper motors. The hexagonal shape design creates the perfect angular deviation required to implement the three wheel omni-drive system. The stepper motors are secured in place with the use of 3D printed motor mounts. The motors used in the project are Nema 17 bipolar stepper motors. The stepper motors are connected to an AdaFruit Pi HAT Servo Shield.

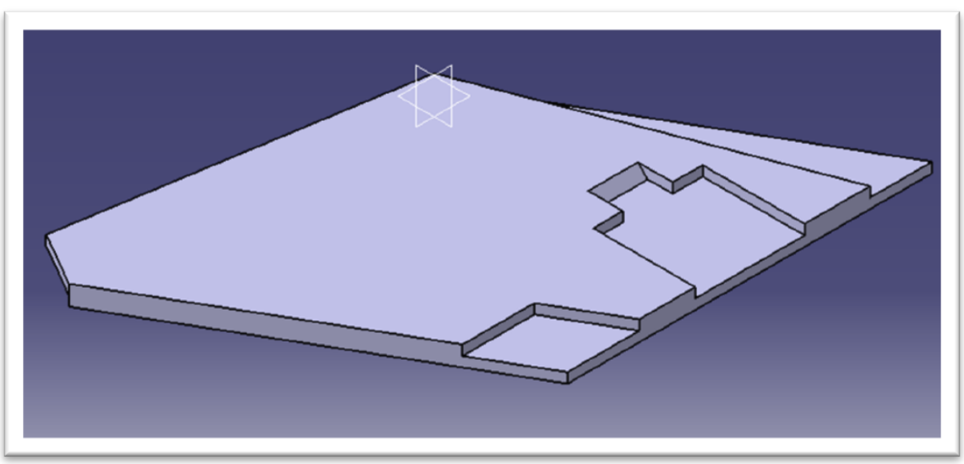


Figure 2: Sectional Design of Robot Chassis

The microprocessor used in the project is a 1.2 GHz Quad-Core ARM Cortex A53 64-Bit Processor on the Pine A64 board with 2GB RAM [3] (Figure 3). The Pine A64 board can run with the Linux based Ubuntu operating system from a MicroSD card. It has built-in ports and attachable modules that allow for easy implementation of the project. The Pi-2 bus position at the top of the board allows for the use of motor shields from the Raspberry Pi Foundation and similar organizations. These motor shields are required to send signals and power motors on the chassis. The on-board port for the Wi-Fi and Bluetooth module enables the communication over wireless networks. The focus of this project is the interconnection of multiple robots using Wi-Fi communication.

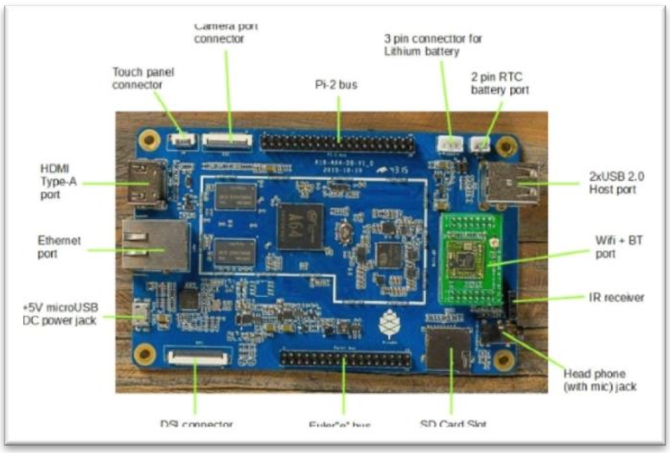


Figure 3: Pine A64 board [4]

2.4 Software Implementation

The robots are configured to implement ROS nodes and topics. "*ROS is an open-source, meta-operating system for your robot. It provides the services you would expect from an operating system, including hardware abstraction, low-level device control, implementation of commonly-used functionality, message-passing between processes, and package management"* [5]. It also provides tools and libraries for obtaining, building, writing, and running code across multiple processors. ROS is executed by using various nodes to publish and to subscribe to topics. These topics have access to system information such as sensor data and motor velocity. The topics have messages that are used in the exchange in the information. The information is transferred from one robot to another through wireless ad-hoc communication. The ad-hoc communication is established by creating the Wi-Fi network for robots [6]. The Wi-Fi network is created on all the robots with a different IP address to identify each individual robot. After the robots are connected to the network, certain ROS environmental variables have to be declared and values chosen. The two variables used are ROS_MASTER_URI and ROS_IP [7]. The variables can be declared during the launch of roscore and can be overwritten in a Linux terminal. These environmental variables are also declared in each terminal used in a robot. ROS_MASTER_URI determines which robot is the master. In the scope of the project, any of the robots can be chosen as a master. Also, it informs the nodes of the location of the master. ROS_IP exports the IP addresses of the robots to the master robot allowing successful wireless communication. Figure 4, Figure 5a and Figure 5b describe the configuration of the wireless networks using the ROS system.

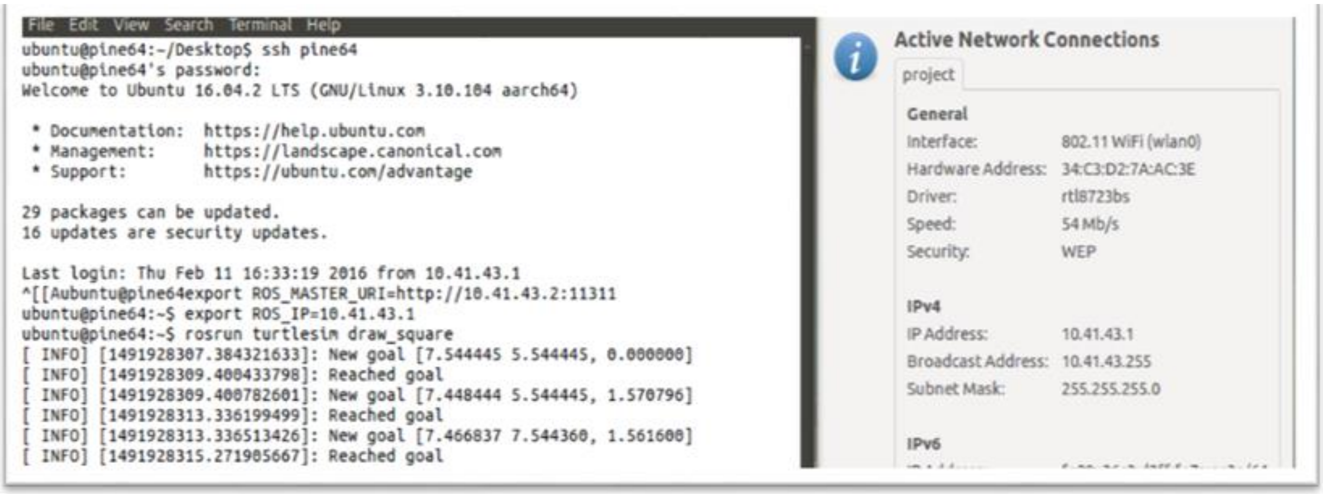


Figure 4. Screenshot of a Robot Communicating to Master

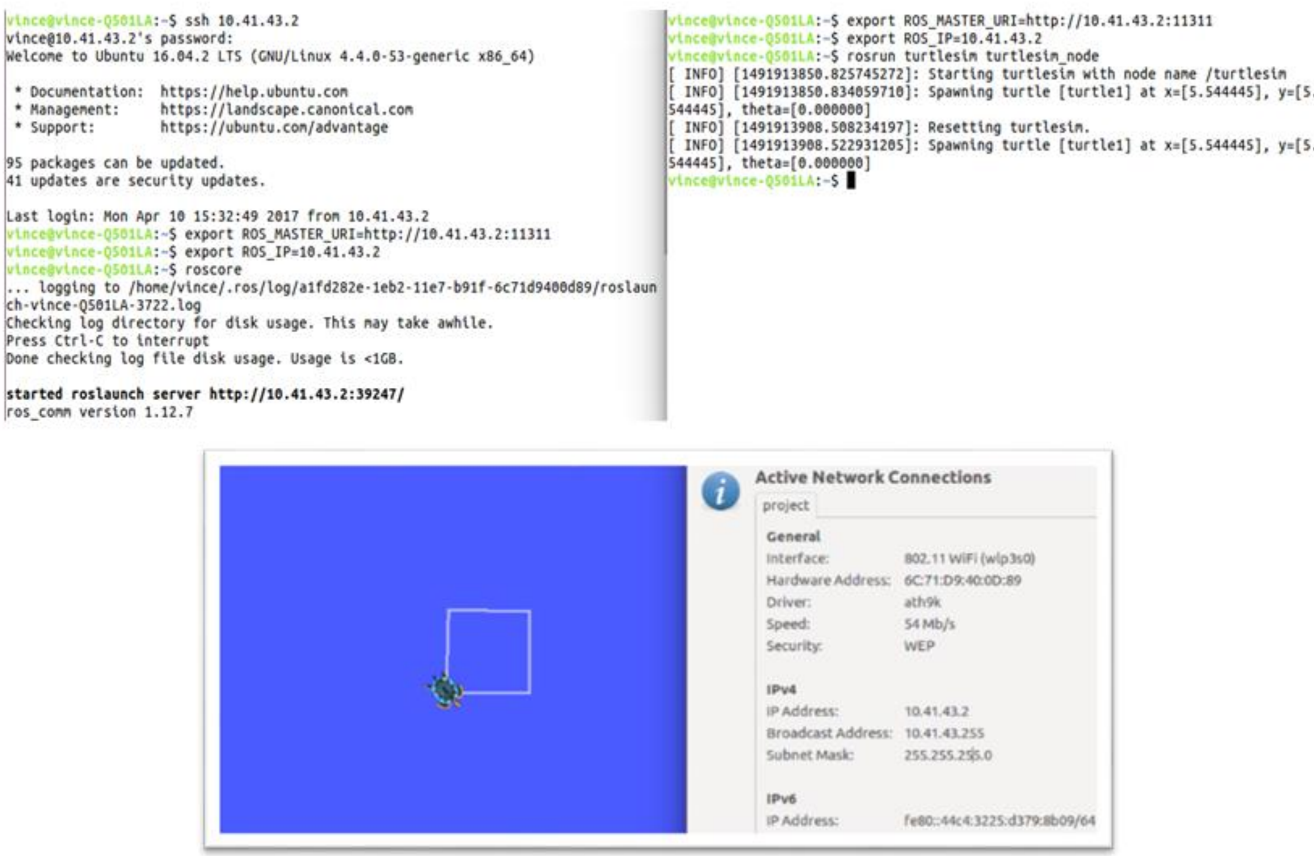
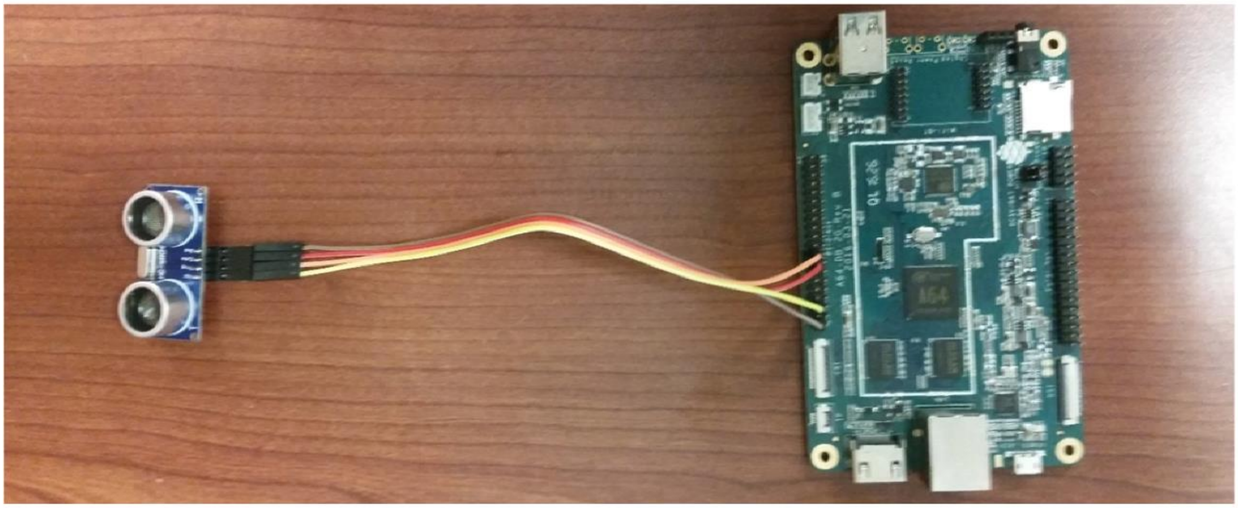


Figure 5a and 5b. Screenshots of Master Robot

Figure 6 shows the connection of the ultrasonic sensors to the PineA64 board for testing purposes. Multiple sensors share a voltage source and ground pin, respectively. The ultrasonic sensors use the general-purpose input/output pins (GPIO) to collect necessary data. Each sensor



utilizes separate GPIO pins to prevent an error with the data.

Figure 6. Ultrasonic Sensor Attached to PINEA64 board

Bill of Materials

Table 1: Bill of Materials of Four Robots

Item	Unit Price	Quantity	Total
Pine A64 +2GB Board	$29.00	4	$111.60
Wi-Fi 802.11 BGN/ Bluetooth 4.0 Module	$9.99	4	$39.96
Lithium Polymer Battery	$21.99	4	$87.96
Nema17 Stepper Motor	$11.60	12	$139.20
Elegoo HC-SR04 Ultrasonic Module Distance Sensor	$9.99	24	$239.94
Adafruit 16-channel PWM/ Servo HAT	$18.50	3	$55.50
Sandisk Ultra 32 GB micro SD Class 10	$13.95	3	$41.85
60mm Aluminum Omni Wheel	$13.95	12	$167.40
6mm Aluminum Mounting Hub	$6.49	12	$77.48
			Total: $936.29

Table 1 provides the total cost for the four robots used in the project. This price is reasonable due to the number of robots required for the project. The cost of an individual robot is approximately $234.

3. Conclusion

The applications of decentralized multi-robot systems have dramatically increased in many companies. Each of the four robots designed in this project consists of a three wheel omni-drive system with a Pine64A microprocessor system and eight ultrasonic sensors. ROS provides an open-source platform allowing user control of the hardware abstraction, low-level device control, implementation of commonly-used functionality and more. The project applies the decentralized robot system to the movement of several robots in a specific pattern at equidistance with communication only occurring between the robots. In addition, the total number of robots incorporated into the system can be increased to more than the robots implemented. The system used in this project provides a learning platform for students in robotics courses with a cost-effective price. In order to apply this project to use in the educational environment, the algorithm must be developed with several functions and classes as well as a main function. The program's architecture design allows easy implementation in a classroom environment and makes a substantial contribution to the robotic learning community.

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Anti-Spill Cup

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ABSTRACT

Essential tremor (ET) is a very common, complex and progressive neurological disorder involving movement. The two most common types of tremors are essential tremor and Parkinson's disease. ET is categorized as an involuntary movement that most often affect hands. This movement occurs in the form of rhythmic jerks known as vibrations. In its simplest form, a vibration is considered as the oscillation or repetitive movement of an object. Excessive shaking can make certain voluntary actions such as holding a cup full of liquid difficult to accomplish. In the market there exists a product (Lift Ware Steady), a spoon, the purpose of which is to counteract involuntary movements caused by a hand tremor. Hence, the idea of designing and implementing an Anti-Spill Cup. The purpose of the artifact is to counter-act unintended movements, maintaining the cup at equilibrium while hand vibrations occur thus decreasing the likeliness of the liquid being spilled. A mechanical control technique called AVC (Active Vibration Control) is used. This approach is used in the automotive industry. Engines and transmissions are highly vibrating systems; to counteract this effect, the AVC method is utilized. It also overcomes the limitations of a passive vibration control mechanism. For the Anti-Spill Cup, the hand oscillations are measured by the means of a sensor (accelerometer). This signal is at that point fed to a microcontroller where an algorithm is written to offset the tremor vibrations. An actuator signal is generated by the microcontroller which is then fed to an actuator (servo) that will induce motion to the mechanical system for controlling and stabilizing the cup's trembling. The process of designing this product from start to finish includes design of the cup, study and assembly of electronics, and the development of a control algorithm.

1. INTRODUCTION

Tremor is defined as "…unintentional, rhythmic muscle movement involving to-and-fro movements (oscillations)" reported by the National Institute of Neurological Disorders and Stroke. Tremor is most common in such diseases as Parkinson's which creates a public view of tremor as being associated with the elderly. Approximately 60,000 Americans are diagnosed with Parkinson's and more than 10 million people worldwide live with Parkinson's; 70% of those affected by Parkinson's have tremor [1]. After age 70 tremor increases to the point where professional help is often sought. Hand tremor can make such tasks as writing, eating and drinking difficult, in part due to the shaking of the hand. The project's goal is to build an Anti-Spill Cup, in a shape comparable to a coffee mug. It consists of a microcontroller and a servo motor installed on the handle, with an accelerometer placed on the base of the cup.

2. OBJECTIVE

The objective of this project is to develop a control-based cup that will stabilize liquid from excessive shaking caused by tremor. Essentially, the cup will offset the vibrations caused by the tremor, thus reducing the amount of liquid spilled out of the cup. The Anti-Spill cup , by nature of its components, will be easy to use and not bulky. The cup will allow those suffering from tremor to drink with a lessened spill rate. Due to the economic challenges facing the elderly, the Anti-spill cup should be affordable.

3. BACKGROUND STUDY

There is no cure for tremor; however, there are many treatments that can reduce its affect. There are drugs that lessen the extent of shaking and surgeries such as Deep Brain Stimulation that uses implantable electrodes to send high frequency electrical signals to the thalamus, effectively disabling the tremor. The second surgical option is Thalamotomy, drilling into the skull and inserting electrodes onto the thalamus and creating a lesion, eradicating all tremors. There are side effects from these surgeries, such as problems with motor control of speech, visual and learning difficulties and issues with balance.

There are situations where mechanical vibrations may be desirable or undesirable. Undesirable vibrations are those that generate annoyance and/or danger, degradation and structural failure, etc. In fact, high levels of vibration are inherent in design of machines and vehicles. For example, reciprocating engines generate forces which must be insulated from the inside of the vehicles, and crankshaft vibrations should be reduced to extend their useful life. In the case of tremor, the force is produced by the reciprocating/involuntary movement of the muscles which provokes the vibrations.

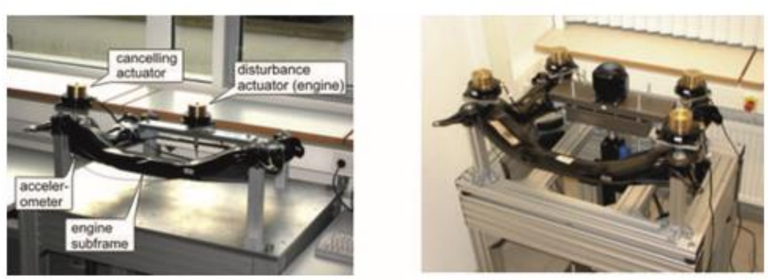

Figure 1:Engine Mount

If the objective is to reduce vibration to an acceptable level, there are three general ways of doing this: The first one is isolation, i.e. to suppress or reduce excitations. The second approach is modification of the S-system, so that the vibrations are acceptable. The final approach is active vibration control, which absorbs or dissipates vibrations using electronic devices.

Active vibration isolation systems are closed loop feedback systems consisting of sensors, controllers and actuators. This approach is used in the automotive industry to dissipate vibrations caused by the transmission systems. In most cases, the sensor is piezoelectric accelerometer that senses the excitation of the passive engine mount. The acceleration signal is then processed by the controller. The controller generates a canceling signal that is fed to a power amplifier. The amplifier converts the controller's low-voltage signal to an actuator current. The actuator in this case is a servo. The force generated by the actuator cancels the primary disturbance signal resulting in a lower vibration signal compared to the initial one [3]. Figure 2 shows an active control system schematic.

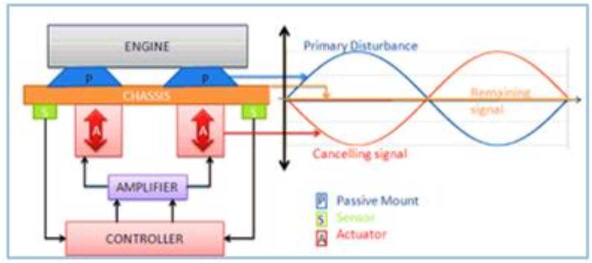

Figure 2: AVC (Active Vibration Control) System

4. COMPONENT LIST

In this section, the parts used in the project will be introduced as follows.


Figure 3: Accelerometer

<u>Accelerometer: ADXL335</u>

- Analog Sensor
- Measure 3 axis's – X, Y, Z
- 3-volts to be powered fully
- High response rate
- Variable g selection up to 3g

Figure 4: SC-1251MG Servo

<u>Servo Motor: SC-1251MG</u>

- High response rate - 4.8V: 0.10 sec/60
- High torque - 4.8V: 97.2 oz-in
- Waterproof
- Metal gearing with aluminum casing


Figure 5: Teensy 3.2 Microcontroller

<u>Teensy 3.2 Microcontroller</u>

- 32 bit ARM Cortex-M4 72 MHz CPU
- Arduino IDE compatible
- 3.3V fully powered
- 256 kb flash memory
- Small size: 1.4 x 0.7 in.

5. SYSTEM DESIGN

5.1 Hardware Design

The cup design can be broken into three pieces, shown in Figure 6. The cup itself with removal bottom, the handle, and lastly the servo decouple connecting the servo to the cup. For all designs the 3D modeling software CATIA is used, which is displayed in Figure 7. The 3D printing is utilized to make the parts. An aspect that deeply influenced the design was the fact that the cup itself should be dishwasher-proof. To accomplish this, the cup cannot have any components that would be damaged during the dishwasher operation. The servo decouple removes the handle along with the servo from the cup and the removal cup bottom removes the accelerometer from the cup, allowing safe cleaning.

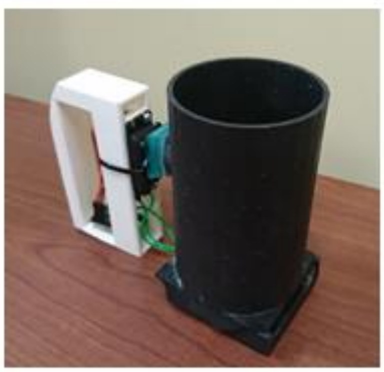

Figure 6: Designed Cup

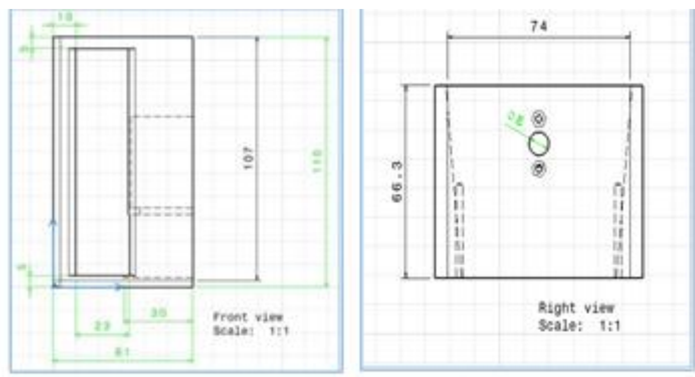

Figure 7: CATIA Drawing of the Cup

The size of each piece of the cup is listed as follows:

- Cup Dimensions: 5.25” x 3.12” x 2.81” in.
- Bottom portion dimensions: 2.6” x 2.5” x 0.7” in.
- Total weight (Cup & bottom): 5.14 oz.

There are two 3D printers available in the 3D printing lab at Vaughn College, the Makerbot Replicator and Form 2; both have unique properties which lend to pros and cons. The cup and sliding mechanism are printed with the Form 2 and the handle is printed on the Makerbot Replciator. The cup and servo decouple both require fine details, which is ideal for the Form 2, and the handle is large and requires no fine details, making it ideal to be printed on the Makerbot Replicator.

Cup

The cup itself must contain a bottom portion which is removable to house the accelerometer. The bottom portion will slide out for ease of use. The first prototype design on CATIA was a threaded removal bottom. However, that design was improved for two reasons. The threaded design would be relatively weak when 3D printed with the Form 2; also it adds extra complexity to the printing, taking into consideration fitment and sanding. It is easier to make a compartment that slide outs, like a draw on a dresser. The current design is effective but also weak when taking into consideration the Form 2 resin material properties. The bottom portions are made into a smaller section to accommodate the removable section. After continuous use, these sections broke off. A new design with thicker walls will address this issue. But for testing purposes the previous cup is still used.

Servo decouple

The servo attaches to one half of the decouple and the other half attaches to the cup; this piece slides out from the bottom of the cup allowing the cup to be put into a dishwasher. Fine detail was required for this part; the Form 2 printer was used. To the end of the design, the dimensions of the servo is chosen as 1.02" x 0.4" x 1.03" in^3 and the weight as 0.14 oz.

Handle

The handle must be sized to fit the average human hand. The purpose is to house the servo and microcontroller, attached is the servo decouple to the cup. To the end of the design, the dimensions of the handle is chosen at 2.3" x 1.02" x 4.56" in^3 and the weight as 1.41 oz.

Motor

The SC-1251MG servo motor was chosen for a multitude of reasons. A servo motor is easy to use; there are no special mounts required. Most of all servos on the market have mounting points on the frame and even come with hardware to mount them. This servo features a low-profile servo, meaning it is shorter in length compared to a standard servo, allowing the handle to be smaller in size. The motor is rated at a high torque of 97.2 oz-in at 4.8V. The 3D printed cup when filled holds a maximum of 24 oz. The motor is quite common in the RC car world, meaning that purchasing options are plentiful. This motor is commonly used for Formula 1 RC car steering systems, which require a high response rate since the cars move at over 100 mph. The response rate is rated at 0.1 sec/60°. The servo motor is also waterproof with metal gears and an aluminum casing, allowing for higher reliability compared to most plastic geared servos. The price is a modest $60.

Cup's Moment of Inertia

To develop the control algorithm, the cup's moment of inertia was derived. The moment of inertia is an object's resistance to change in the rotation direction. In the case of the Anti-Spill cup, the lower the moment of inertia, the faster the motor can turn the cup, resulting in faster reaction times to vibrations. To determine the moment of inertia, the following equation is used:

$$i = \left(\frac{1}{3}\right)\left(\frac{M}{L}\right)[D^3 + (L-D)^3 \quad , \tag{1}$$

where M is the mass of the object, D is distance from the point of moment to the bottom of the object and L is the total length of the object. Given the use of Equation (1), the moment of inertia is at the two points of 66mm and 67mm, where the value of moment of inertia is 0.2261. Table 1 shows a chart of some random distances of D to display the change of moment of inertia.

Table 1: Moment of Inertia points

Distance (D)	Moment of Inertia
20 mm	0.5577
38 mm	0.3506
66mm	0.2261
95mm	0.3505
148mm	1.2449

As seen in Table 1, the lowest value of moment of inertia is 66mm, which is the prime value of moment of inertia. The section of the cup where the motor mounts to the cup is modified to the distance of 66m to provide the lowest resistance to change the rotation to the smallest possible.

5.2 Software Design

Microcontroller

The Teensy 3.2 microcontroller is used for this project due to its small size and satisfactory processing power. The original option for a microcontroller was the Arduino Nano. The Nano is almost the same size as the Teensy at 1.8” x 0.6” compared to 1.7” x 0.7”. But the Teensy has a faster processor. The need for this fast processor was due to the requirement of a high response rate from all our components in order to properly control vibrations. A faster processor means commands from the accelerometer are accepted and acknowledged faster and commands to the servo are sent faster. The Teensy 3.2 is compatible with its own IDE software, but it is also compatible with the Arduino IDE, which in turns means the program can be written in C language.

ADXL345 Triple Axis Accelerometer. Pitch & Roll calculation

```
#include <Wire.h>
#include <ADXL345.h>
#include <Servo.h>

Servo servo1;
ADXL345 accelerometer;

void setup (void)
{
 Serial.begin(9600);
```

```
// Initialize ADXL345
Serial.println("Initialize  ADXL345");

if (!accelerometer.begin())
{
  Serial.println("Could not find a valid
ADXL345 sensor, check wiring!");
  delay(500);
}
// Set measurement range
```

```
  // +/-  2G: ADXL345_RANGE_2G
  // +/-  4G: ADXL345_RANGE_4G
  // +/-  8G: ADXL345_RANGE_8G
  // +/- 16G: ADXL345_RANGE_16G

accelerometer.setRange(ADXL345_RANG
E_16G);
  servo1.attach(3);
   servo1.writeMicroseconds(600); // set
servo to mid-point
}

void loop(void)
{
  // Read normalized values
  Vector norm =
accelerometer.readNormalize();

  // Low Pass Filter to smooth out data. 0.1 -
0.9
  Vector filtered =
accelerometer.lowPassFilter(norm, 0.5);

  // Calculate Pitch & Roll
  int pitch = -(atan2(norm.XAxis,
sqrt(norm.YAxis*norm.YAxis +
norm.ZAxis*norm.ZAxis))*180.0)/M_PI;
  int roll  = (atan2(norm.YAxis,
norm.ZAxis)*180.0)/M_PI;

  // Calculate Pitch & Roll (Low Pass Filter)
  int fpitch = -(atan2(filtered.XAxis,
sqrt(filtered.YAxis*filtered.YAxis +
filtered.ZAxis*filtered.ZAxis))*180.0)/M_P
I;
  int froll  = (atan2(filtered.YAxis,
filtered.ZAxis)*180.0)/M_PI;

  // Output
  Serial.print(" Pitch = ");
  Serial.print(pitch);
  //Serial.print(" Roll = ");
 // Serial.print(roll);

  // Output (filtered)
  Serial.print(" (filter)Pitch = ");
```

```
  Serial.print(fpitch);
  //Serial.print(" (filter)Roll = ");
  //Serial.print(froll);
  Serial.println();


  // servo1.write(pitch);
  delay(15);
}
```

Servo Neutral Position

```
int servoPin = 3;                    // pin
attached to servo
int pos = 1500;                      //
initial servo position

void setup() {
  pinMode(servoPin, OUTPUT);
}

void loop() {
  digitalWrite(servoPin, HIGH);        // start
PPM pulse
  delayMicroseconds(pos);              // wait
pulse diration
  digitalWrite(servoPin, LOW);         //
complete the pulse
    // Note: delayMicroseconds() is limited to
16383µs
    // see
http://arduino.cc/en/Reference/DelayMicros
econds
    // Hence delayMicroseconds(20000L-
pos); has been replaced by:

  delayMicroseconds(5000-pos);        //
adjust to 5ms period

  delay(15);                           // pad
out 5ms to 20ms PPM period
   Serial.print(pos);
    Serial.println();

}
```

5.3 System Testing

The components utilized in this project are now being discussed. The left image of Figure 8 displays the actual hardware configuration, while the right image shows the design schematic.

The overall idea of perfoming tests is to understand and verify the functionity of all components. The first step was to test the acclerometer by running a code that allows the collection of raw values and the conversion of the raw data into degree values. After verifying that the code works and gives values in degrees, the servo is added to the design. So the accelerometer is positioned at different angles to provide the rotation of the cup. The idea is to verify that the servo responds sufficiently fast, based on the movement of the accelerometer.

The cup uses an accelerometer, which by default will plot all values in the unit of m/s^2. With some modifcation of the code, the values can be plotted in degrees. Figure 9 contains a graph with the values plotted in degrees. The blue portion of the graph indicates these values while the red signal represents a filtered signal.

Displayed in Figure 8 is the testing configuration, consisting of the servo motor, microcontroller and accelormeter. This set up is used to test the main program and individual components before mounting them on the cup itself. The wiring is the same as used in the cup; the parts can simply be moved onto the cup after the testing is completed.

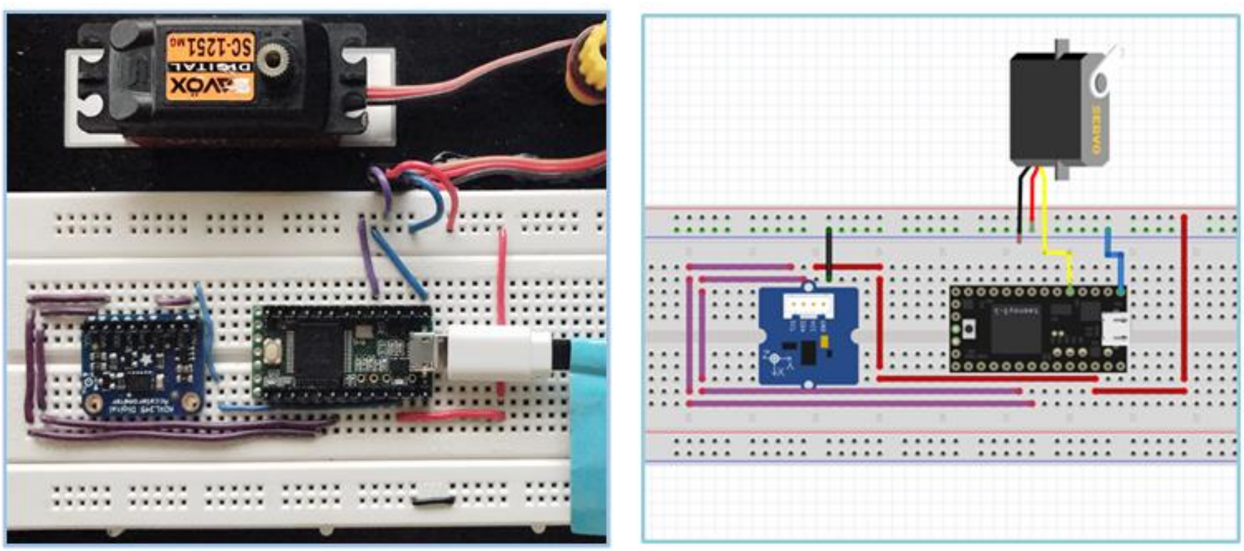

Figure 8: Testing Configuration and Schematic

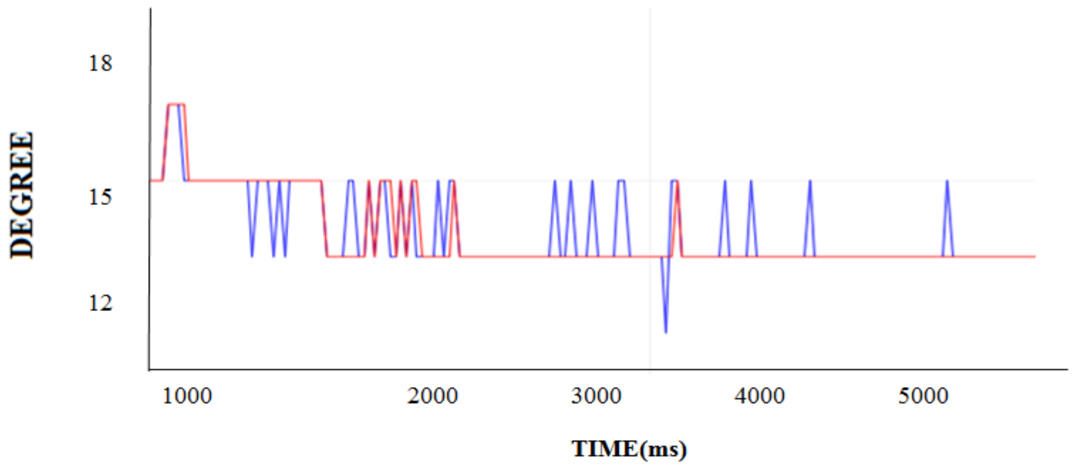

Figure 9: Testing Configuration and Schematic

5. CONCLUSION

The Anti-Spill cup was built using a hobby servo, a Teensy microcontroller, and a variable g accelerometer, together with the CAD design and 3D printing technology. The objective of this project is to improve the life quality of those living with tremor. With the ability to make drinking an easier and less embarrassing task, the cup has the potential to improve everyday lives of those with tremor. With a cost effective design, a user friendly interface and the ability to reduce vibrations, the Anti-Spill Cup will be very helpful to those who suffer from tremor. The development of this cup will encourage the creation of similar devices to improve the lives of those whose activities involve excessive shaking.

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