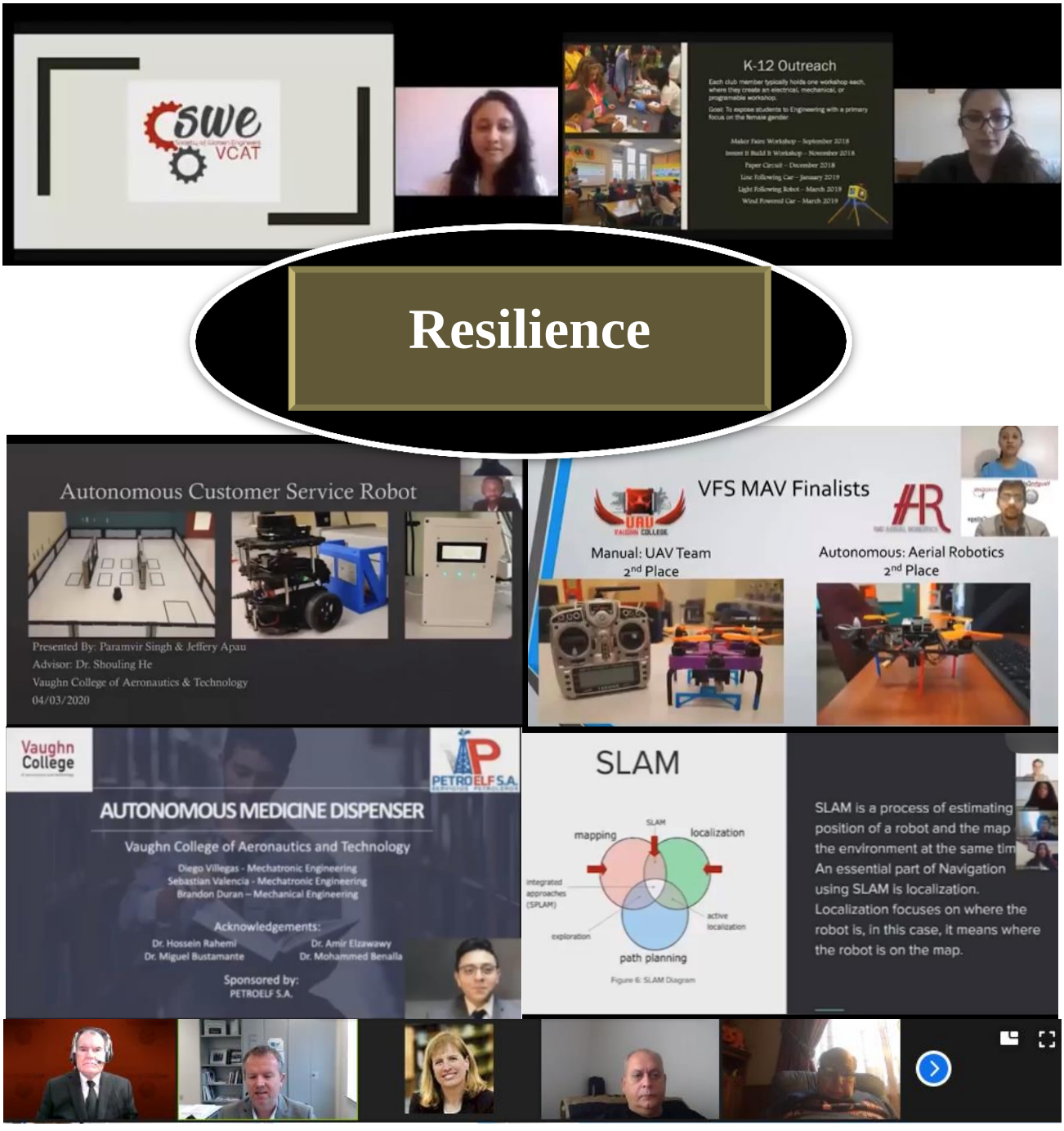
Vaughn College Journal of Engineering and Technology
May 2021



"The greatest glory in living lies not in never falling, but in rising every time we fall." - Nelson Mandela

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 the best student research papers.

Given the rapid pace of technological change, the Journal is intended to assist Vaughn engineering students in the development of an appreciation of lifelong learning to meet their future professional challenges. The ultimate goal of the journal is to engage and prepare students for their future in engineering research and innovation. VCJET further strengthens student learning outcomes related to critical thinking, problem solving, communication, and teamwork. These learning outcomes, embedded in engineering and engineering technology programs, are further developed through the activities outlined in this publication. The events reported in this journal also contribute to student development of leadership and entrepreneurial skills.

A journal paper project must be produced and investigated in a manner that 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 related to computational mechanics, solid mechanics, mechatronics, robotics, avionics, electronics, and other topics pertinent to the engineering and engineering technology fields.

Author and Technical Editor: Dr. Hossein Rahemi
Journal Editor: Dr. Margaret Ducharme

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Contents

A Brief Review of Vaughn College's Twelfth Annual Technology Day Conference, May 29, 2020

Vaughn students, faculty, alumni, and industry professionals convened on May 29, 2020 for the Virtual Twelfth Annual Industry Advisory Meeting and Technology Day Conference through a Zoom meeting. Advisory Council members were given updates on recent developments in the Engineering and Technology Department, such as preparation for the 2020 ABET initial accreditation of mechanical engineering and electrical engineering programs, direct and indirect data collection, "1 through 7" student outcomes assessment, the continuous improvement process, HSI-STEM grant activities, including the development and implementation process of four stackable manufacturing certificate programs leading to a BS in advanced manufacturing program, establishment of four manufacturing centers (PLC & Automation, composite, additive manufacturing, and CNC machining), students' engagement in STEM through technical clubs, students' chapter of professional qualifications, and scholarly activities.

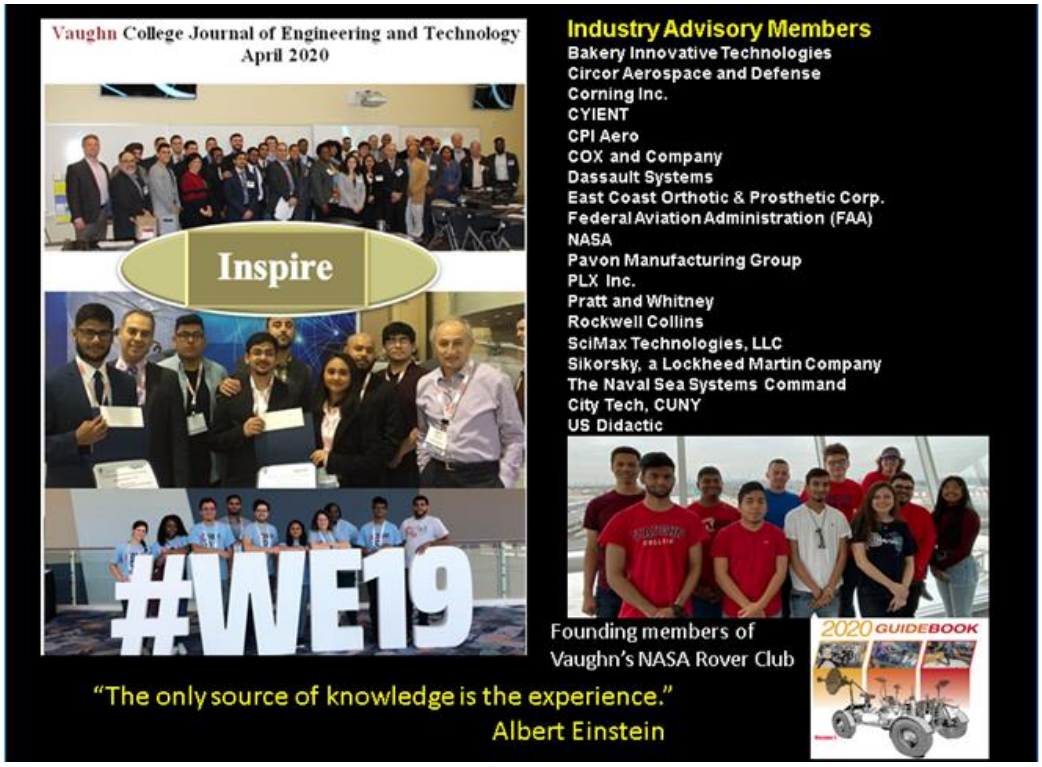
Prof. Manuel Jesus hosted this Virtual event and introduced all presenters; he also served as the moderator for the clubs and capstone presentation sessions of this annual gathering.

Vaughn College's President, Dr. Sharon DeVivo, welcomed the guests and thanked our advisory members and alumni for their active participation and support of the institution and students' success and encouraged our advisory board and alumni to continue helping Vaughn's graduating students with internship and positions opportunities during these challenging times. Academic Vice President, Dr. Paul LaVergne, thanked our advisory members and introduced a possible reopening plan of school for the fall semester, through both remote and campus meetings for the smaller class sizes involved with hands-on learning.

Dr. Hossein Rahemi, Chair of Engineering and Technology Department, thanked the advisory members for their continuous support and valuable feedback in every aspect of the department's programs and student success. He updated the advisory members about the department's preparation for 2020 initial accreditation of ME and EE programs and provided an overview of the department's documented assessment process in measuring and attaining student outcomes for these two programs. He explained how the department is currently in the completion process of ME and EE self-study reports based on 8 ABET criterions (Students, PEOs, Student outcomes, Continuous improvement, Curriculum, Faculty, Facilities, and Institutional support). He provided insights regarding the assessment of these programs and the continuous improvement process based on direct and indirect measures. As a direct measure, the department employs the Faculty Course Assessment Report (FCAR), the Capstone Degree project evaluation survey, and the laboratory evaluation survey to assess attainment of student outcomes through courses and programs. Also, constituent evaluation surveys (Employer, Internship supervisors, Tech Day capstone advisory evaluation surveys) are used as a direct measure to analyze attainment of student outcomes. As in direct measure, the department uses student exit and alumni surveys to assess student outcomes. As of fall 2019, the department modified its assessment methodology, and the program faculty determined appropriate performance indicators and subsequent assessment tools for each outcome. Based on this assessment methodology, each outcome is subdivided into

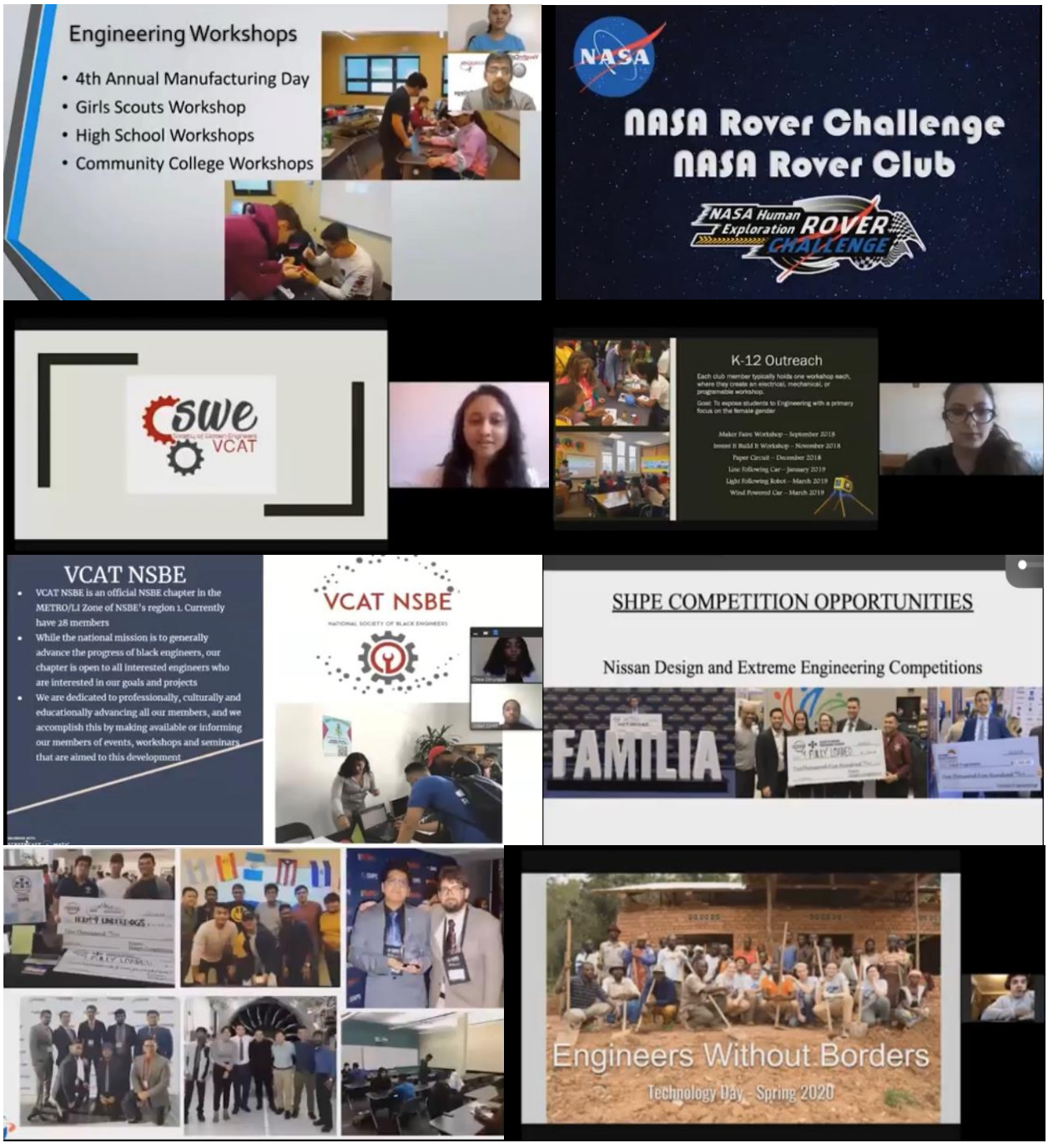
performance indicators (PI) to provide additional information about our outcome assessment and to target improvement, should it be warranted. Course tasks and assignments are used as a direct-measure to assess performance indicators of each specific outcome. As part of this continuous improvement process, the department collects course and program data, evaluates results, and develops assessment and actions to address any shortcomings within the program.

Dr. Rahemi informed advisory members about the Department of Education Title III HSI-STEM grant funded activities including the establishment of four manufacturing centers (PLC & Automation, 3D additive manufacturing, composite, and CNC machining), completion of three stackable certificate programs in Computer Aided Design & Additive Manufacturing, Composite Manufacturing, and CNC machining and their current approval by New York State Education Department (NYSED). Currently, the PD and grant management team are in the development process of an additional certificate program in UAS with 5 courses and 12 credits. Courses from stackable certificate programs will lead to a BS in Advanced manufacturing program. This program has a total of 128 credits, and 67 of those credits are part of technical courses from 4 stackable certificate programs as well as 29 credits in engineering science. Dr. Rahemi's presentation provided insight into students' professional and scholarly activities, including the success of the Vaughn College Robotics team at the 2019 regional VEX U Robotics competitions, as well as their qualification to participate in the 2020 VEX U World Championship. He announced the participation of Vaughn's UAV team as finalists in both manual and autonomous categories of The Vertical Flight Society (VFS) for the Annual Micro Air Vehicle (MAV) Student Challenge competition on May 13, 2019 at University of Pennsylvania. Vaughn's UAV team completed this competition successfully and the team received 2nd place awards for both autonomous and remote control categories with a $1750 check. This is the third year in a row that Vaughn's UAV team won the top award in this challenging competition. Also, he talked about student involvement and success in scholarly activities including participation, presentation, and publication in technical conferences such as ASEE, AIAA, SWE, LACCEI, COMSOL, SHPE, Southern Biomedical Engineering, and International Mechatronics.



Robotics, UAV, SWE, EWB, NSBE, Rover, and SHPE Clubs' presentation
11:00 am to 12:00 pm

Each technical club and student chapter of a professional society provided a 7 minute presentation on their annual activities, including their involvement in technical competitions, organizing and hosting STEM workshops, community outreach activities, assisting Vaughn College in hosting regional High Schools and College Robotics competitions, hosting Robotics and Drone workshops during Vaughn's Annual Manufacturing Day and International Drone Day, hosting STEM workshops during SWE and SHPE annual conferences, participating in extreme engineering and Nissan design challenges of the SHPE annual conference, as well as other activities that helped them with internship and career opportunities. Also, they talked about their involvement in scholarly activities including participation, presentations, and publications in technical conferences. The videos of their presentation provide more details of these activities.



Vaughn's Robotics, UAV, Rover, EWB, SWE, NSBE, and SHPE Presentations

Student Technical Paper Presentation, 12:00 pm to 2:00 pm

Vaughn graduating students gave presentations about their capstone research projects during afternoon paper sessions of the 2020 Virtual Technology Day Conference. Total of nine capstone papers as listed below were presented during the afternoon session of this Virtual event.

1. **Modular Torque Wrench Extension with Heads-up Display**
   Authors: Atif Saeed, Juan Aguirre Rodriguez, and Juan Castano
   Program: Mechatronic Engineering
   Advisors: Dr. Mohammed Benalla
2. **Remote-Controlled Yard Utility Bot – RYUB**
   Authors: Michael Panico, Jacqueline Oricchio, Jonahz Hernandez
   Program: Mechatronic Engineering
   Advisors: Dr. Miguel Bustamante
3. **Harvesting Power– Modular High-Rise Cooling Tower Hydro Turbine – Commercial Economizer Design**
   Author: Ariel A. Ferrera
   Program: Mechanical Engineering
   Advisors: Dr. Amir Elzawawy
4. **The Autonomous Life Emergency Rescue Transmitter (A.L.E.R.T.)**
   Authors**:** Peter Kalaitzidis, Sagufta Kapadia, and Syed Misbahuddin
   Program: Mechanical and Mechatronic Engineering
   Advisors: Dr. Amir Elzawawy
5. **The Autonomous Medicine Dispenser**
   Authors: Diego Villegas, Sebastian Valencia, and Brandon Duran
   Program: Mechatronic and Mechanical Engineering
   Advisors: Drs. Mohammed Benalla, Hossein Rahemi, Miguel Bustamante, and Amir Elzawawy
6. **Search and Rescue Rover Delivery System for Multirotor Drones**
   Authors: Valeriya Larina, Aderet Pantierer, Shmuel Pantierer
   Program: Mechanical Engineering
   Advisors: Dr. Amir Elzawawy
7. **Autonomous Customer-Service Robot**
   Authors: Paramvir Singh and Jeffery Apau
   Program: Electrical Engineering
   Advisor: Dr. Shouling He
8. **Soil Probing Robot (SPR)**
   Authors: Andriy Belz, Nurullah Khan,
   Programs: Mechanical and Mechatronic Engineering
   Advisors: Dr. Amir Elzawawy
9. **Implementation of Robot Path Planning and Image Processing**
   Authors: Jason Becker, O. Chloe Eimunjeze, Alyssa Mitchell, Bruce Tenesaca
   Programs: Mechatronic Engineering
   Advisors: Drs. Mohammed Benalla and Hossein Rahemi


MODULAR TORQUE WRENCH EXTENSION WITH HEADS-UP DISPLAY
Presented By: Atif Saeed
Juan Aguirre Rodriguez
Juan Castano
Faculty Advisor:
Dr. Mohammed Benalia
INTRODUCTION
Torque control is a critical component of the assembly process within the manufacturing industry
Within the aerospace manufacturing and maintenance industry, line workers manually torque bolts[1]
Many discrepancies can be made with current technology
HARVESTING POWER– MODULAR HIGH-RISE COOLING TOWER HYDRO TURBINE
•COMMERCIAL ECONOMIZER DESIGN
Vaughn College of Aeronautics
Mechanical Engineering
Ariel A Ferrera Final Presentation Video Trim.mp4
Ariel A. Ferrera
INITIAL PROBLEM STATEMENT
Vaughn College of Aeronautics
Mechanical Engineering
Cooling Tower
Pump
Chiller
Pump
Hydro-Turbine to be placed at the outlet of the cooling tower utilizing the change of potential to kinetic energy of the rushing water.
Flowing water passes through the venturi like turbine connected to a generator. Electricity can be stored or used elsewhere for facility usage.
R.C. Yard Utility Bot
Presented by Jacqueline Oricchio, Michael Panico, and Jonahz Hernandez
03 PROJECT CONCEPT
Vaughn College
PETROELF S.A.
AUTONOMOUS MEDICINE DISPENSER
Vaughn College of Aeronautics and Technology
Diego Villegas - Mechatronic Engineering
Sebastian Valencia - Mechatronic Engineering
Brandon Duran – Mechanical Engineering
Acknowledgements:
Dr. Hossein Rahemi
Dr. Amir Elzawawy
Dr. Miguel Bustamante
Dr. Mohammed Benalia
Sponsored by:
PETROELF S.A.
How it works
Key-Locking Door
Pill Dispensing Chute
Touch Screen
Dispensed Pill Location

Students' Capstone Paper Presentation

Best Paper Award Recipients

The top 3 research papers were selected by our Industry Advisory members as the recipients of the Best Student Paper awards of this session. The winning papers included: Two First place research paper winners, 1) **Modular Torque Wrench Extension with Heads-up Display** by Atif Saeed, Juan Aguirre Rodriguez, and Juan Castano, 2) **Autonomous Medicine Dispenser** by Sebastian Valencia, Brandon Duran, Diego Villegas; second place research paper winner, "**Harvesting Power–Modular High-Rise Cooling Tower Hydro Turbine**" by Ariel A. Ferrera; and two third place research papers winners, 1) **Implementation of Robot Path Planning and Image Processing** by Jason Becker, Chloe Eimunjeze, Alyssa Mitchell, Bruce Tenesaca, 2) **ALERT** by Peter Kalaitzidis, Sagufta Kapadia, and Syed Misbahuddin..

In conclusion, Dr. Rahemi, congratulated all capstone paper and technical club presenters and he announced that the Vaughn Community is impressed us with the quality of this work and proud of these student accomplishments.

He extended his gratitude to the federal department of education HSI-STEM funding support for all STEM activities and student engagements in hands-on technical clubs, competitions, and scholarly activities. He thanked the industry advisory board and alumni for their feedback and continuous support in every aspect of the department and for student success. Finally, he thanked and expressed his sincere appreciation to Prof. Jesus for hosting and managing the entire four hour event and for engaging both students and participants throughout the process.

Supplemental Instruction

Supplemental Instruction (SI) is a student academic assistance program which increases academic performance and retention through the use of collaborative learning strategies. The SI program at Vaughn targets challenging mathematics, engineering, and physics courses and provides regularly scheduled, out-of-class, peer-facilitated sessions giving students further opportunity to process the information learned in class. Supplemental instruction is a proactive approach to student learning and engagement which increases student persistence and retention. In an effort to increase learning effectiveness, during the spring of 2009 a formal supplemental learning program was introduced. In addition, during the spring of 2012, as part of the Hispanic-Serving Institution (HSI) STEM grant, the SI program has been further enhanced to assist and improve student understanding in fundamental engineering and engineering technology courses. In these courses, such as statics, dynamics, strength of materials, AC/DC circuits, Robotics, automation, and Computer Aided Design, highly talented students who have already completed those courses are selected to sit-in on the classes for a second time, with the instructor, and to serve as a designated Supplemental Instructor (SI) for these courses and laboratory exercises. The student SI is assigned the task of reviewing class lectures, conducting problem solving sessions and communicating with the faculty member about the areas where students need reinforcement for successful course completion. This SI program was initiated in conjunction with the Teaching and Learning Center (TLC). The current HSI-STEM title III grant provides additional funding ($60,000/year, 2016-2021) to further enhance the SI program through more fundamental courses that can improve the attainment of student learning outcomes in all STEM related programs.

The student SI is scheduled for ten hours per week to assist students in the fundamental engineering and engineering technology courses. This includes three hours per week that the SI attends the class with the instructor for the second time, and another seven hours per week to assist students with problem solving sessions. For fall 2020 the student supplemental instructors and their schedule are presented in the following table.

Fall 2020 SIs for the Corresponding Courses and Course Schedule

Course	Faculty	Supplemental Instruction Tutor	Zoom Class Schedule	Zoom SI Tutoring Schedule
MEE340	Dr. Rahemi	**Samantha Vitez**	See Zoom Hours	**M-F: 1:30pm-5:00pm**
MEE215	Dr. Jahnke	**Jack Sze**	W: 2pm-3:30pm	**T: 9am-12pm; 2pm-5pm** **W: 9am-10:30am** **Th: 10am-2pm** **F: 12pm-3:30pm**
MEE220	Dr. Jahnke	**Misael Marquez**	Th: 2pm-3pm	**T: 12pm-2pm; 5pm-6pm** **W: 12pm-3:30pm** **Th: 10am-2pm** **F: 12pm-3:30pm**
EGR220	Dr. Rahemi	**Raphael Cordina**	M, W: 10am-11:30am	**T, Th: 2pm-4pm** **F: 10:30am-12pm; 1pm-2:30pm**
MEE370	Dr. Rahemi	**Samantha Vitez**	See Zoom Hours	**Sat, Sun: 2pm-5:30pm**

MEE260	Dr. Elzawawy	**Raphael Cordina**	M, W: 12pm-3:30m	**M, W: 12:30pm-2pm** **T, Th: 10am-12pm**
ELE220	Dr. Bustamante	**Deno Jordan**	See Zoom Hours	**M: 9am-11m** **T: 4pm-10pm**
MEE345	Dr. Benbelkacem	**Almaz Abdrasulov**	See Zoom Hours	**M-F: 5pm-7pm** **Sat, Sun: 11am-1pm**
ELE117	Dr. Benalla	**Isa Al-Maktoum**	T, Th: 12pm-2pm	**F-Sun: 7am-10am** **T: 6pm-8pm**
MCE101	Prof. Tang	**Kevin Tsang**	M: 5:30pm-9pm	**W: 5:30pm-9pm**
ELE326	Dr. He	**Timothy Tullio**	T, Th: 3pm-4pm; 5:30pm-6pm	**T, Th: 1:30pm-3pm**
ELE230	Dr. He	**Nocholas Bentancur**	Th: 12pm-2pm	**T, Th: 11am-12pm**
ELE350	Dr. Bustamante	**Deno Jordan**	See Zoom Hours	**W: 9am-12pm** **Th: 8am-11am; 5pm-6pm** **F: 9am-12pm**

2020 Department's Activities and Highlights

1. **STEM related student engagement (Technical Competitions, STEM workshops and Conferences):**
   - **2020 West Virginia Regional VEX U Robotics Tournament:** On Saturday, March 6 2020, Vaughn College's Robotics team participated at the West Virginia VEX U Robotics Regional Tournament. Vaughn's robotics team finished first during qualifying matches and finished 2nd place in "Robot Skills"
   - **2020 Southern Biomedical Engineering Conference:** From March 6-8, two Vaughn engineering students, Atif Saeed and Sebastian Valencia, along with faculty advisor, Dr. Mohammed Benalla, participated and presented their research project in the 36th Southern Biomedical Engineering Conference in New Orleans LA. The presentations took place between 6:00 PM and 7:30 PM. Atif Saeed presented "Haptic Thermal Feedback Prosthetic Brain-Controlled Arm" and won third place reward for undergraduate category while Sebastian Valencia presented "Autonomous Medicine Dispenser". Both papers were accepted for publication in the Biomedical Science Instrumentation Journal.
   - **2020 Vaughn's Robotics Tournament:** On Friday, February 28, 2020, Vaughn College hosted its sixth Annual VEX U College Regional Robotics Tournament. A total of thirteen college teams participated at this event. The participant teams included Aquidneck Island Robotics (AIR), Johnson & Wales University (JWU1), South Dakota Schools of Mines and Technology (MINES), New Jersey Institute of Technology, New York Institute of Technology (NYIT), (NYIT2) and (NYIT3), Florida Polytechnic University (POLY1), Rutgers University (SKAR), University at Buffalo (UBR), Vaughn College of Aeronautics and Technology (VCAT) and (VCAT2), and Worcester Polytechnic Institute (WPI). In this regional completion, Vaughn's robotics team won

both first place "Robot Skills" and "Excellence" awards which qualify them to participate in the 2019 VEX U world championship..

- **2020 Society of Hispanic Professional Engineers (SHPE) National Virtual Conference:** From Oct 26 – 30, a group of eight engineering students from Vaughn College attended the 2020 Society of Hispanic Professional Engineers (SHPE) Virtual Conference. Vaughn's students participated in Innovative challenge, and Extreme Engineering Challenge, as well as various professional development workshops that aimed to promote leadership, unity, and to expose them to the diverse career opportunities in the STEM fields. Also, Vaughn participated in the career fair session of SHPE national conference, and Vaughn's SHPE chapter received a total of 12 interviews for both internship and full-time positions with companies such as BAE Systems, G.M, DuPont, North Grumman, Honeywell, Medtronic, BP America, and Textron. These interviews resulted in pending Internships and four potential job opportunities.
- **2020 SWE Annual Virtual Conference:** From November 2-13, Vaughn College's chapter of the Society of Women Engineers attended the 2020 Women Engineers Virtual Conference. During the conference, ten members of the chapter had the opportunity to attend leadership seminars and technology talks. In addition to attending seminars, SWE students attended the career fair, and they received interviews with industry leaders such as Johnson & Johnson, Stryker, Medtronic, Blue Origin, Northrop Grumman, Ball Corporation, Air Force Research Laboratory, Boston Technology, Siemens AG, Jacobs Engineering Group Inc., and Southwest Research Institute
- **2020 Vaughn's Technology Day Virtual Conference:** On May 29, Vaughn graduating engineering students gave presentations about their capstone research projects during afternoon paper sessions of the 2020 Virtual Technology Day Conference. Nine capstone papers were presented during afternoon session of this Virtual event. The top 3 research papers were selected by our Industry Advisory members as the recipients of the Best Student Paper awards of this session. The winning papers included: Two First place research paper winners, 1) **Modular Torque Wrench Extension with Heads-up Display** by Atif Saeed, Juan Aguirre Rodriguez, and Juan Castano, 2) **Autonomous Medicine Dispenser** by Sebastian Valencia, Brandon Duran, Diego Villegas; second place research paper winner, "**Harvesting Power–Modular High-Rise Cooling Tower Hydro Turbine**" by Ariel A. Ferrera; and two third place research papers winners 1) **Implementation of Robot Path Planning and Image Processing** by Jason Becker, Chloe Eimunjeze, Alyssa Mitchell, Bruce Tenesaca, 2) **ALERT** by Peter Kalaitzidis, Sagufta Kapadia, and Syed Misbahuddin..
- **2020 LACCEI International Conference:** From July 27-31, Vaughn's engineering and technology students, along with Dr. Hossein Rahemi, department chair and PD of HSI-STEM, attended the LACCEI 2020 Virtual Conference. Three Vaughn student team research papers were accepted for presentation and publication in the LACCEI 2020 international conference; Three Vaughn student papers, as listed below, were selected to compete among ten finalists for the student paper session, and two submitted papers were accepted for the poster session of LACCEI 2020 as well.
    - ✓ **"Modular Torque Wrench Extension with Heads-up Display"** by Atif Saeed, Juan Aguirre Rodrigues, and Juan Castano

- ✓ **"Autonomous Medication Distributor Through Implementation of Bresenham's Line Algorithm"** by Brandon Duran, Diego Villegas, and Sebastian Valencia
- ✓ **"Development of an Advanced Robotics Program for Middle and High School students"** by Ryan Tang Dan and Maharshi Patel.

From 11 am to 1 pm on Tuesday, July 28, three of our student team papers, as listed above, were presented to the international conference audience during the student paper session of LACCEI 2020. Vaughn's student team paper presentation by Atif Saeed, Juan Aguirre Rodrigues, and Juan Castano covered design, development, and manufacturing process of **Modular Torque Wrench Extension with Heads-up Display** and was selected by judges as a **first place award recipient of the 2020 LACEEI student paper session competition** Also, from 2:30 pm to 4:30 pm on Wednesday, July 29, two of Vaughn's student team posters were selected for the LACCEI 2020 Virtual poster session competition. Vaughn's student poster by Brandon Duran, Diego Villegas, and Sebastian Valencia outlined their degree capstone project **"Autonomous Medication Distributor through Implementation of Bresenham's Line Algorithm"** was selected by judges as a **first place award recipient in the 2020 LACEEI student poster session competition**

2. **Lab Equipment, Laboratory Enhancement and Development:**

- ❖ In fall 2020, we received all related equipment for the UAS lab (Dual Quadrotor for indoor unmanned aerial vehicle (UAV) research, Quanser Aero USB, and other equipment and accessories to design and construct a drone), and currently lab tech is completing the installation of the UAS lab. This lab will be used to provide students with hands-on skills in courses within both the UAS certificate program and the BS in Advanced Manufacturing program.
- ❖ The support of title III grant allowed the department to complete establishment of Vaughn's state-of-the-art 3D prototyping innovation center in spring 2018. In fall 2020, with the recommendation of the 3D/CNC curriculum developer and lab tech, the following items has been added to this center to further engage students in hands-on STEM activities
  - ✓ Peopoly Phenom L MSLA 3D printer for mass production of high-precision for students and technical clubs projects
  - ✓ 3D USA Precision 350 extruder, filament, nozzle pack, puller wheel and accessories
  - ✓ SV2 printable circuit board (PCB) printer to support implementation of stackable manufacturing certificates and BS in advanced manufacturing program,
- ❖ In spring 2019, renovation of our CNC lab at the Aviation Training Institute (ATI) building in Astoria has been completed and department completed installation of CNC (CNC lathe, CNC milling, and 3D Coordinate Measuring Machine-CMM) equipment at this location. In fall 2020, with the recommendation of CNC lab tech, a Plasma table for metal cutting has been added to this lab. CNC lab will be used to teach and conduct hands-on courses toward our new approved CNC manufacturing certificate program.

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3. **Hosting STEM related Conferences, Workshops, Seminars, STEM Outreach and other Department's related Activities:**
   - **2020 Vaughn College 6th VEX U Robotics Regional Tournament:** Vaughn College hosted its sixth VEX U College Regional Robotics competition on Friday, February 28th, 2020. A total of thirteen college teams participated at this event. Vaughn faculty members and staff served as the judges, and Vaughn's robotics team served as manager, referees, announcers, and event planners for this event. In this regional competition, Vaughn's robotics team won the first place Skills award and the Excellence award.
   - **2020 Vaughn College 6th High School Robotics State Qualifier Competition:** Vaughn College hosted its sixth high school state qualifier robotics competition on Saturday, February 29th, 2020. A total of 58 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk counties attended the February VEX state qualifier at Vaughn College. Vaughn faculty members and staff served as the judges, and Vaughn's robotics team served as manager, referees, announcers, and event planner for this event. An alliance of Newfield High School and Centereach High School won the tournament championship, while a team from Newfield High School won the High School "Excellence" Award, Jericho High School won the "Design" Award and KG Computech won "Robot Skills" and Middle School "Excellence" awards. Tournament champions, "Excellence" Award, "Design" Award and "Robot Skills" Winner and are qualified to participate in the New York State VEX Championship.
   - **2020 Vaughn's STEM Day Workshop:** The engineering and technology department hosted its second STEM Day workshop for community college students on Friday, March 6, 2020. The participants of Vaughn's STEM Day workshop were students and faculty from Passaic, Queensborough, Bergen community colleges. In the morning session, Vaughn's STEM Pathway Liaison and STEM project director, Dr. Hossein Rahemi, talked about Vaughn College's program offerings in engineering and engineering technology disciplines, as well as student involvement in various STEM related clubs and professional activities. From 10:30 am to 11:30 pm, Avionics program coordinator, Prof. Mudassar Minhas, introduced audiences to the aircraft avionics system related to radar, navigation and communication. From 11:30 pm to 12:30 pm, Prof. Manuel Jesus, CNC and Additive manufacturing Curriculum developer, hosted a workshop at Vaughn's 3D Maker Space Center on 3D additive and subtractive manufacturing process using various 3D priming machines
   - **6th Annual Manufacturing Day Virtual Conference:** The Department hosted the 6th annual manufacturing day conference on Friday, October 30, 2020 (10 am to 1 pm) to celebrate National Manufacturing Day. The guest speakers addressed Vaughn community, faculty, and invited guests about current manufacturing innovation in the area of AM Journey to Production, Drone Manufacturing and ISO Manufacturing Standards, Digital Manufacturing and the IIOT: Success with a Single Platform, Industry 4.0-Part II, and additive manufacturing with consumer grade low cost 3D printers.
   - **6th Annual Manufacturing Day STEM Workshops:** On Friday, October 30. 2020, In a parallel session, from 10 am to1 2:00 pm, Vaughn's Robotics, SWE, and UAV clubs organized and hosted virtual STEM workshops for the high school students. These workshops covered Robotics and UAV design & autonomous programing, as well as team preparations for the 2020-2021 VEX U Robotics and VFS-MAV competitions
   - **12th Annual Technology Day Virtual Conference:** On Friday, May 29, 2020, the

Engineering and Technology department hosted its Twelfth Annual Industry Advisory Meeting and Technology Day Virtual Conference. Dr. Rahemi, updated Advisory Council members on recent developments in the Engineering and Technology Department, such as preparation for the initial 2020 EAC ABET accreditation of ME and EE programs, HSI-STEM grant activities, including the development process of stackable manufacturing certificate programs in CNC machining, Composite, and 3D additive and subtractive manufacturing that lead to a BS in advanced manufacturing program, establishment of manufacturing laboratories (CNC machining, composite, additive manufacturing, and PLC & automation), and plans for development of the UAS laboratory and certificate program. PD updated advisory members with grant supported STEM activities, student engagement and outreach activities. Each technical club shared their annual club activities and accomplishments to the audiences of Virtual Tech day Conference, and finally capstone degree presenters talked about their innovative research project. The top 3 research papers were selected by our Industry Advisory members as the recipients of the Best Student Paper awards of this session. In conclusion, Dr. Rahemi congratulated all capstone paper and technical club presenters, and he expressed the pride of the Vaughn community in their accomplishments.

- **Industry Connection and Engineering Seminar Series:**
  - **An introduction to NASA and NASA Internship Opportunities:** on Tuesday, Feb 25, 2020, Mr. Matthew Pearce, National Aeronautics and Space Administration (NASA) education programs specialist and Ms. Rosalba Giarratano, Pathways Intern at the Goddard Institute for Space Studies, addressed the Vaughn community as part of College's Industry Connection Seminar series with a presentation on topics related to the space station opportunities for researchers, students, and educators, on the NASA climate change research initiative (CCRI), on the NASA Moon to Mars mission and research benefits for humanity, and on current internship options for students, STEM engagement, and NASA's internship application and interview process.
  - **An Overview of Summer Internship Programs with Stryker and Rolls-Royce:** On Tuesday, March 3, 2020, Ariel Ferrera, a senior student in mechanical engineering, and Jacqueline Oricchio, a senior mechatronic engineering student who participated in a summer internship program with Stryker and Rolls-Royce, addressed the Vaughn community about their summer internship projects. Ariel Ferrera's internship with Stryker was involved in designing and analyzing medical device tools such has reamers and oscillating saw blades to reduce thermal necrosis in orthopedic knee surgery, and Jacqueline Oricchio's internship program with Rolls-Royce consisted of taking 3d pdfs of engines and making the proper adjustments to them. These adjustments included putting components in their proper locations, adding textures to the models, or separating the engines into separate modules.
  - **An introduction to NASA, NASA Goddard Space Flight Center, NASA Goddard Institute for Space Studies and NASA Internship Opportunities:** on Thursday, Feb 11, 2021, Mr. Matthew Pearce, National Aeronautics and Space Administration (NASA) education programs specialist and Ms. Rosalba Giarratano, Pathways Intern at the Goddard Institute for Space Studies, addressed

the Vaughn community as part of the College's Industry Connection Seminar series. For this Microsoft Teams Virtual event, both Ms. Rosalba Giarratano and Mr. Pearce's presentation covered topics related to an overview of NASA, NASA Goddard Institute for Space Studies, and NASA STEM Workforce Challenges. They talked about all available STEM Internship, Fellowship, and other career opportunities with NASA and NASA's internship application and interview process.

- **Power System Integration for Aerospace Industry:** On Friday, February 19, 2021, Mr. Carlo Asaro, a senior Aircraft Avionics Systems Engineer for Sikorsky, addressed the Vaughn community as part of the College's Industry Connection Seminar series. For this virtual event seminar, Mr. Asaro talked about topics related to the high horse power motor, PLC, high power cables conductors, electronics conduit design and the manufacturing process within the aerospace industry (Attachment#2-Power System Integration for Aerospace Industry)..
- **Electrical Safety and Consideration:** On Tuesday, March 23, 2021, Mr. Carlo Asaro, a senior Aircraft Avionics Systems Engineer for Sikorsky and an adjunct faculty at Vaughn College, addressed the Vaughn community as part of the College's Virtual Industry Connection Seminar series on the topic of Electrical Safety Considerations. The overall topic of the presentation was safety first. The serious nature of this topic was addressed through a discussion regarding tragic workplace accidents related to servicing motors accidentally left in a powered-on state. Personal electrical safety equipment such as probes, high voltage resistant gloves, and foot pads were shown as effective measures against fatal injuries.
- **Update on new FAA drone Rules that go into effect April 2021:** On Thursday, April 15 from 11 am to 12 pm, as part of the College's industry connection seminar series**,** Ms. Loretta Alkalay, an aviation attorney, specializing in issues related to compliance with federal aviation regulations, including drone rules, who is also an adjunct professor at Vaughn College updated the Vaughn community on new FAA drone rules that go into effect April 2021, including operations over people rule and remote ID rule.

❖ **Career Advisement Day – Career Conversations with Students:** On Thursday, September 17, 202, the engineering and technology department arranged and its 2nd Annual Curriculum and Career Advisement day with students in engineering and engineering technology programs. Project Director (PD) with coordination of Students Activities and Engagement department organized this virtual event to provide all engineering and engineering technology students with curriculum and career advisements. This virtual event covered topics related to curriculum as well as activities in which students should participate in order to enhance their career opportunities while studying at Vaughn

❖ **ME and EE annual progress report:** In September 2020, the PD submitted the 2019-2020 annual progress report for both ME and EE programs including information/updates on: new/refurbished facilities, faculty and staff, and preparations for ABET evaluation to the NYSED. Every September an annual report needs to be submitted to the NYSED until the department receives EAC- ABET accreditation for both of these programs.

- **STEM Outreach:**
  - ✓ **John F. Kennedy High School Robotics Competition:** On January 25th, 2020, Vaughn's Robotics Club assisted John F. Kennedy High School in hosting its first high school robotics competition on Saturday January 25th, 2020. A total of 34 regional high schools attended the January VEX state qualifier. Five members of the Vaughn robotics teams acted as referees, judges, and event manager for this regional competition.
  - ✓ **Tiny Whoop Drone Race:** On Saturday, February 1st 2020, Vaughn's UAV team organized and hosted its 2nd Tiny Whoop Race in partnership with the Cradle of Aviation Museum for middle school and high school students.
  - ✓ **Freeport High School Regional State Qualifier Robotics Competition:** On Saturday, February 1st, 2020, Freeport High School hosted its regional state qualifier robotics completion, and more than thirty five regional high schools participated in this competition. Nine members of Vaughn's robotics team, along with faculty members, participated in assisting Freeport High School with this regional tournament.
  - ✓ **Harvey School District Robotics Competition:** On Saturday, February 15th, Harvey School District hosted its fifth high school robotics competition on Saturday, February 15th, 2020. A total of 57 regional high schools participated in this competition. Two members of Vaughn's robotics team attended as referees for the event.
- **2020 EAC ABET Team Virtual site visit (Nov 15 – 17) for the initial accreditation of Mechanical and Electrical Engineering Programs:** From Sunday, November 15 to Tuesday, November 17, 2020, the Engineering Accreditation Commission (EAC) of ABET made a virtual visit to Vaughn College for the purpose of initial EAC ABET accreditation of mechanical and electrical engineering programs. Both Mechanical and Electrical Engineering programs have been developed, with the support of HIS-STEM grant funding, and received NYSED approval in academic year 2015-2016. In academic year 2020, we had 7 graduates in ME and 2 graduates in EE programs. A request for the initial EAC-ABET accreditation was submitted in January 2020, with a schedule for the fall 2020 site visit. In July 2020, the department uploaded self-study reports for both programs into the ABET site, and all supporting materials were uploaded to a sharepoint for review by the ABET visiting team. From November 15 through November 17, EAC ABET team conducted a zoom virtual visit with Vaughn's faculty, students, alumni, senior administration, and industry advisory members, and during Tuesday's exit briefing they informed us that both programs are in compliance with all ABET criteria requirements. We expect to receive ABET's final accreditation statement for both of these programs in August 2021.
- On Monday, June 22nd, the engineering and technology department chair updated the board of trustees on department annual activities, assessment & preparation for the fall 2020 ABET virtual site visit, new stackable manufacturing certificate programs that lead to a BS in advanced manufacturing, student engagement (UAV, Robotics competitions, conference, and scholarly activities), the industry connection seminar series, and other department related issues.
- In August 2020, the department chair, with the assistance of the Grants Manager, completed and submitted an application for the UAS certificate program to the NY State

Education Department for their review and approval. This certificate program has five courses with a total of 13 credits and provides a "well-rounded" education to prospective engineers and technicians in UAS design, application, operation, and regulations. This certificate program will cover design, construction, application, operation, and system integration for Unmanned Ariel Vehicles (UAV). In this certificate program students, through courses such as introduction to UAV, drones rapid prototyping, and application for land surveying will gain hands-on experience in designing, constructing, and operating a UAV for a specific application, with consideration of payloads types, communication and control systems. Also, though the drone law and remote pilot course, students will learn about FAA's new part 107 regulation, and the course prepares them with required aeronautical knowledge testing to assist them in the acquisition of the remote pilot certificate for operating UAS. At the end of the program, students will have a strong foundation in UAS design, construction, application and operation.

- On Thursday, January 9, 2020, the department chair organized a meeting with the Engineering and Technology Industry Advisory Board to discuss new changes to EAC of ABET regarding Criterion 3, Student Outcomes and Criterion 5, curriculum. In this meeting, he updated advisory members on the department assessment process, the self-study development, and the preparation for the initial EAC-ABET accreditation of mechanical and electrical engineering programs. Dr. Rahemi thanked advisory members for their continuous support and input in every aspect of the department, student success, and the institution. His presentation covered items regarding changes to ABET's student outcomes and curriculum, as well as new "1 through 7" student outcomes assessment based on performance indicators.

Laboratories Development, Upgrade and Enhancement

For the past several years, as a result of the Title III grant funding support, the engineering technology department has been able to establish several state-of-the-art-laboratories such as the Thermo-Fluid lab, the Robotics and Control System lab, the automation lab, the 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 current title III grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students," will further enable the engineering department to develop stackable certificate programs leading to a BS in advanced manufacturing program as well as laboratories associated with this program. This new grant supports the engineering department towards the development and enhancement of state-of-the-art CNC machining, 3D Makerspace, composite manufacturing, and UAS laboratories. 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.

In the 2020-2021 academic year, the department completed purchase of the following laboratory equipment:

1. Equipment for UAS lab (Dual Quadrotor for indoor unmanned aerial vehicle (UAV) research, Quanser Aero USB, and other equipment and accessories to design and construct a drone) with a total price **$77,000**. Lab tech is completing the installation of UAS lab, and this lab will be used to provide students with hands-on skills in courses within both UAS certificate program and BS in Advanced Manufacturing program.
2. Plasma table for CNC metal cutting with accessories, cost, **$2,590.75**
3. Peopoly Phenom L MSLA 3D printer for mass production of high-precision for students and technical clubs projects, cost **$2,909.03**
4. 3D USA Precision 350 extruder, filament, nozzle pack, puller wheel and accessories for 3D Makerspace center, cost **$14,157.80**
5. SV2 printable circuit board (PCB) printer for 3D Makerspace center to support implementation of stackable manufacturing certificates and BS in advanced manufacturing program, cost **$20,146.00**

This laboratory equipment allows Vaughn to provide students with practical STEM hands-on training in CNC, Composite, UAS, and 3D additive and subtractive manufacturing, that is current with today's manufacturing industry standards.

Vaughn's CNC and 3D Makerspace Centers

Manufacturing Certificate Programs

For the past 3 years, with the support of HSI-STEM grant funding, the project director and grant management team completed establishment of four manufacturing centers with the state-of-the-art laboratory equipment. Those are, 3D innovation center completed in fall 2018, CNC Manufacturing Center completed in spring 2019, PLC and Automation completed in fall 2019, composite manufacturing lab completed in spring 2019. These centers will be used to teach and conduct hands-on courses within our newly developed and NYSED approved manufacturing certificate programs in 1) Computer Aided Design for Additive and Subtractive Manufacturing Certificate, 2) Composite Design and Manufacturing certificate, 3) CNC Subtractive Manufacturing Certificate, 4) UAS Design, Application, Operation, and Regulation certificate. Courses within these stackable certificate programs will provide students with practical hands-on knowledge and skills that are current in today's manufacturing industry.

Courses from all stackable certificate programs will lead to a BS degree in Advance manufacturing program, and students will be able to use those courses as tech electives towards BS mechanical engineering technology and mechanical engineering programs within the engineering and technology department.

I) Computer Aided Design for Additive and Subtractive Manufacturing Certificate Program

The support of the new Title III grant will assist the department in the complete establishment of Vaughn's state-of-the-art 3D prototyping innovation center by adding a Form Labs Fusion (SLA Powder based SLS printer capable of printing fully assembled products with minimal cleanup), 3D Systems HD3600 3D printer, Fusion laser engraver, and a Forged Desktop Injection Molding Machine. In the academic year 2018, the department added the Digilab 3D Printer (model D45-01), and one ProJet MJP 2500 3D Printer. In fall 2020, the department added SV2 printable circuit board (PCB) printer to this lab to support implementation of stackable manufacturing certificates and BS in advanced manufacturing program.

This certificate program will cover manufacturing systems utilized in the additive and subtractive manufacturing fields. Students will gain hands-on experience developing CAM programs for Haas CNC machines. Rapid prototyping will be covered via 3D Printing systems such as Form 2, Stratasys Fortus 250 MC, 3D Systems ProJet 3600, and Magics 3D printing software. Reverse engineering through the use of 3D scanning will be explored to develop parts using Artec Eva Scanners, Catia, Geomagic, and SolidWorks. At the end of the program, students will have a strong foundation in real world computer-aided design, problem-solving skills, and fabrication techniques.

1) CDE 117: Computer Aided Design with Solidworks
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Prerequisites: None
Course Description: The goal of this course is to provide an introduction to engineering graphics and computer-aided design engineering standards using Sold Works CAD software. This is accomplished by examining the role of the computer in the present design process. Topics include computer graphics, computer aided-design and drafting, (CAD) geometric construction, orthographic projection, dimensioning, section and auxiliary views, detail drawings, 3D modeling, and introduction to assembly drawings. Students will also gain skills in developing part assemblies for 3D printing.

2) CDE 385: Catia Fundamentals
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Co-requisites: CDE 117
Course Description: This course introduces students to Catia, one of the leading parametric modeling packages in the aerospace and automotive manufacturing industries. Practical solid modeling techniques will be covered in a project based approach. Real world examples will take students through the various Catia Workbenches such as Part Design, Assembly Design, Drafting, Wireframe Surface Design, and Generative Sheet Metal Design. Students will gain the knowledge required to design parts suitable for 3D printing and manufacturing through hands on lab projects.

3) CDE 375: Computer Graphics for Additive Manufacturing
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Prerequisites: CDE 117, CDE 385
Course Description: Students will work on computer graphics techniques related to additive

manufacturing through the use of 3D printing and 3D scanning equipment. Image acquisition in 2D and 3D will be covered in Adobe Photoshop and Artec Scan Studio, where students will learn about graphic image formats, and 3d scan data processing. Autodesk 3ds Max and Maya will be used as a tool for fast 3D surface development STL file repair. Reverse engineering will be covered through the use of Artec 3D scanners in conjunction with Solid Works and Catia surface modeling techniques. Students will learn to operate and maintain production quality 3D printers, such as the Fortus 250MC FDM printer, Form2 SLA printer, and Makerbot range of 3D printers.

4) CDE 487: Catia for Prismatic Machining and Subtractive Manufacturing
Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours
Prerequisites: CDE 117, CDE 385
Course Description: This course will present the basics of CAM (Computer Aided Machining) and subtractive manufacturing with the Catia CNC Prismatic Machining Workbench. Computer controlled three axis milling and drilling will be covered extensively through the use of real time simulation and program verification. Fundamental milling operations consisting of facing, profile contouring, pockets, drilling, curve following, point to point, and surface machining will be covered in detail. The CATIA prismatic machining module will be used to virtually design and machine a series of parts suitable for output on the Nomad desktop CNC and HAAS CNC machines. Finally, design verification techniques will be explored with the Vericut CNC simulator. Upon completion of the course, students will feel a sense of accomplishment in part design, development, and manufacturing.

II) Composite Certificate Program

This certificate program provides a "well-rounded" education to prospective engineers and technicians who are interested in composite materials. Students will be introduced to the analysis of composite materials, along with hands-on experience in composite manufacturing. Students will also be introduced to mold fabrication and adhesive bonding of composite and metals, which is an integral part of composite manufacturing. Finally, students will be exposed to the most common and latest Non-Destructive Inspection (NDI) equipment and methods and techniques used in the field of composite inspection.

1) Introduction to Engineering Materials
Credits and Contact Hours (lecture/laboratory): 3 credits, 3 lecture hours
Prerequisites: None
Course Description: The purpose of this course is to present to students the basic principles necessary to understand structure-property relations in engineering materials. The student will be introduced to concepts of structure from bonding to microstructure. They will then study the relationships between structure and property of a material. Properties ranging in nature from mechanical, thermal, electrical, optical, magnetic, to chemical will be considered. This course will also introduce the concepts of stress, deformation, and strain in solid materials. Basic relationships between loads, stresses, and deformation of structural and machine elements such as rods, shafts, and beams will be developed. The load-carrying capacity of these elements under tension, compression, torsion, bending and shear forces is considered.

2) Introduction to Composite Materials

Credits and Contact Hours (lecture/laboratory): 3 credits, 3 lecture hours
Prerequisites: None
Course Description: This course introduces basic terminologies used in composite design and manufacturing. An introduction to the various composite manufacturing processes is also introduced. The foundations for the mechanics of composite materials are presented with special emphasis on the long-fibre and woven lamina. On both a micro-mechanics and macro-mechanics level we study the elastic behavior and strength of a composite lamina, i.e. a single layer of unidirectional fibers within a matrix. On the macro-mechanics level, we also study composite laminates (two or laminae stacked together) with respect to elastic behavior, hydrothermal effects, stress, and failure analysis.

3) Introduction to Composite Manufacturing
Credits and Contact Hours (lecture/laboratory): 2 credits, 3 lab hours, 1 lecture hour
Prerequisites: Introduction to Composite Materials
Course Description: Students will work with prepreg carbon fiber unidirectional tape to explore the effects of orientation, balance and symmetry in a laminate. Students will also work with dry glass fabric and liquid epoxy resin to understand the fundamental vacuum bagging, bleeder & breather concepts. Work with prepreg glass and aramid fiber harness-satin fabrics, along with honeycomb and polyurethane foam core materials and the construction of sandwich panel structures and the utilization of laminate "nesting" techniques will be presented in detail. Finally, basic repair methods and techniques will be presented along with the performance of a "wet layup" repair in the lab. The final repaired part will be cut in half for evaluation of the manufactured and repaired panel.

4) Mold Fabrication and Adhesive Bonding of Composite and Metals
Credits and Contact Hours (lecture/laboratory): 2 credits, 3 lab hours, 1 lecture hour
Co-requisites: Introduction to Composite Manufacturing
Course Description: This course is designed to teach students about designing and building molds and fixtures using advanced composite materials. In this course, students will learn about tool design techniques that contribute to both dimensional stability and tool longevity. Students will also gain skills in adhesive bonding technology, while acquiring a deeper understanding of the surface preparation and the fundamental adhesion principles necessary to achieve a good bond to both (polymeric) composite and metallic surfaces.

5) Non-Destructive Testing Techniques for Composite Materials
Credits and Contact Hours (lecture/laboratory): 2 credits, 3 lab hours, 1 lecture hour
Co-requisites: Introduction to Composite Manufacturing
Course Description: This course is designed for students interested in identifying and quantifying defects in new or damaged composite panels using the latest equipment, methods, and techniques. The course is very "hands-on" in nature. Four of the most commonly used NDI techniques will be discussed and practiced in class. These techniques include Visual Inspection, Tap Testing (both manual and instrumented tap testing), Resonance Bond Testing, Acoustic Emission testing, Radiographic testing, and Ultrasonic Inspection.

III) CNC Subtractive Manufacturing Certificate Program

The renovation of the new CNC machine shop at Vaughn's Aviation Training Institute (ATI) building was completed in spring 2019 and this lab with CNC equipment such as HASS VF-2SS CNC milling and cutting machine, Okuma Genos lathe machine, and Coordinate Measuring Machine -CMM for manufacturing part inspection allows the department to offer courses in the CNC manufacturing certificate program. This certificate program will cover CNC manufacturing equipment and systems used in the subtractive manufacturing field. Students will gain hands-on experience developing CAM programs with G-Code, Mastercam, and Catia for the Hass mill and Okuma Lathe CNC machines. Best industry practices for safety, machine shop management, and organization will be demonstrated to students in preparation for entry into the manufacturing field. Part inspection will be conducted using traditional gauges and a granite inspection table along with precision measuring using a Complex Measuring Machine (CMM) from Aims Metrology and Renishaw. Upon completion of this program students will have a strong foundation in real world CNC and CAM problem solving skills for manufacturing.

1) CNC100: Precision Measurement for CNC
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: None
Course Description: This course will introduce students to the world of precision part inspection. After completion of the course, students will understand the multi-view orthographic drawing and its importance in all stages, from development to design and inspection. Students will be able to identify all print abbreviations and use common systems of measurement in their designs. Geometric dimensioning and tolerance concepts will be explored as used in manufacturing. All major instrumentation used in measuring geometric tolerances will be covered, including gauges, micrometers, go and no-go gages, calipers and Coordinate Measuring Machines (CMM). Measurements of surface finish and thread gauges will be covered, in addition to the use of an indicator to perform open setup inspections. At the completion of this course, students will have hands-on experience in the major aspects of part inspection.

2) CNC201 CNC (Computer Numerical Control) Manufacturing I
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Co-requisites: CNC100
Course Description: Students will learn about CNC machine operation though the use of the Haas VF2SS mill and Okuma lathe. Basic CNC terms such as MCU, MDI keys, and the grid coordinate system movements will be explored. Machine tool operations, speeds, feeds, and their use in part development will be covered, in addition to coolant use and chip removal. As the course progresses, students will practice manual machine controls and program execution. Machine shop best practices, organization, and safety will also be covered through hands-on exercises. At the end of the course, students will be able to run a job and prepare all work holding, as they safely operate the machine.

3) CNC202 CNC G code Programming Fundamentals
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: CNC100 and CNC201
Course Description: This course will cover G-Code from both the programmer perspective and the machine operator standpoint. Students will learn to code parts and troubleshoot common problems

in CNC programming. Program blocks, G, L, M, and T codes are explored in relation to programs and subprograms. As the course progresses, conversational, absolute, and incremental programming is covered in addition to subprograms. Program inspection, execution, and testing through the use of a dry run will be covered, along with program edits and coordinate adjustments. Students will leave the course with a strong understanding of the G code programming process in the context of CNC manufacturing.

4) CNC203 CNC (Computer Numerical Control) Manufacturing II
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: CNC100 and CNC201
Course Description: An introduction to 3 and 4 axis CNC machines as a system to run part programs, ranging from small parts to production runs on the HAAS CNC mill and Okuma lathe. Setting tool length and work offsets using manual and probed methods will be explored using the Hass MCU and Renishaw Probe. Tooling geometry, live tooling, and tool selection will be taught for mill and lathe operations. Towards the end of the course, G-Code Program edits using the MCU will be shown in depth to optimize production runs. To insure quality parts in CNC, the importance of part inspection during the machining process will be presented.

5) CNC204 CNC (Computer Numerical Control) CAM Programming
Credits and Contact Hours (lecture/laboratory): 3 credits: 2 lecture hours, 3 lab hours
Prerequisites: CNC100 and CNC201
Course Description: The computer will be explored as both a design tool and a CAM programming tool. Mastercam and Catia software will be used to produce parts and tool paths for CNC manufacturing throughout the course. Students will learn how to develop part designs for machining on the Haas and Okuma range of CNC machines. All the industry standard tooling paths, work holding, and machining operation tasks will be covered in the context of CAM using 2.5, 3 and 4 axis systems. At the end of the course, students will be able to design a part in CAD and deliver post processed G-CODE for manufacturing on the Haas Mill and Okuma Lathe.

IV) UAS Design, Application, Operation, Certificate Program

This certificate program will cover design, construction, application, operation, and system integration for Unmanned Ariel Vehicles (UAV). In this certificate program, through courses such as introduction to UAV, drones rapid prototyping, and application for land surveying, students will gain hands-on experience in designing, constructing, and operating a UAV for a specific application with consideration of payloads types, communication and control systems. Also, though the drone law and remote pilot course, students will learn about FAA's new part 107 regulation, and the course prepares them, with the required aeronautical knowledge test, to acquire the remote pilot certificate for operating UAS. At the end of the program, students will have a strong foundation in UAS design, construction, application and operation.

This certificate program provides a "well-rounded" education to prospective engineers and technicians who are interested in UAS design, construction, application, and operation. Students will gain hands-on experience in designing, constructing, and operating a UAV for a specific application with consideration of payloads types, communication and control systems. Also, though the drone law and remote pilot course, students will learn about FAA's new part 107

regulation, and the course prepares them, with the required aeronautical knowledge test, to acquire the remote pilot certificate for operating UAS.

1) UAS 200: Introduction to Unmanned Aerial Vehicles

Credits and Contact Hours (lecture/laboratory): 3 credits, 3 lecture hours

Prerequisites: None

Course Description: This course provides an introduction to Unmanned Aircraft Systems. The course will cover the design, operations, and system architecture for Unmanned Aircraft Systems as a whole. The course specifically covers UAV airframe configurations, payload types, communications, and ground and vehicle based command & control systems. In addition, instruction covering operations, human factors, risk and accidents will be included. At the conclusion of this course, the student will have an understanding of the entire lifecycle of a UAS product from preliminary design to development and operations, and the multitude of uses of UAVs.

2) UAS 220 - Drone Laws and Remote Pilot Certification

Credits and Contact Hours (lecture/laboratory): 3 credits, 3 lecture hour

Prerequisites: None

Course Description: This course examines the laws that apply to the operation of civilian Unmanned Aircraft Systems – or drones - with a focus on small UAS, those weighing less than 55 pounds. Particular focus will be on the FAA's new Part 107 regulations and preparing students for the aeronautical knowledge test to acquire the Remote Pilot Certificate with small UAS rating. This FAA airman's certificate will allow students to legally fly drones for compensation or hire. The course will also cover rules applicable to flying model aircraft for hobby or recreation and the legal issues raised by drones, such as privacy, law enforcement use, first amendment and freedom of the press, insurance, product liability and property rights in air space. The course will touch on issues of pre-emption and the legality of numerous recently-promulgated state and local laws. It will also survey the approach to drone regulation internationally, including ICAO and EASA's approach, Canada, Mexico and other countries.

The course enables the students to gain the knowledge necessary to gain a valuable FAA certification as a drone pilot and allows students to explore the complexities of these emerging legal issues and the difficulties faced by the drone industry, regulatory agencies and the manned aviation community.

3) UAS 231 - Introduction to Drones Aeronautics

Credits and Contact Hours (lecture/laboratory): 3 credits, 2 lecture hour, 3 lab hours

Prerequisites: None

Course Description: This course covers classical and modern aerodynamics design concepts for both fixed wing and Multi-rotor UAVs. In this course, students are introduced aerodynamics design fundamentals such as lift, drag, thrust and basic flight control elements. The course will cover classical dynamic analysis of Unmanned Aerial Vehicles using structure and fluid mechanics principles. This is in addition to providing an introduction to modern aerodynamics design tools using CAE (Computer Aided Engineering) software.

4) UAS 241 - Drone Applications Series- Land Surveying Using Drones

Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours

Prerequisites: None

Course Description: Land surveying is currently one of the most important applications of drones. In this course student will learn the basic knowledge of photogrammetry, image capturing using unmanned aerial vehicles (UAV), and GPS based mission planning. In addition, students will gain knowledge in post processing and reconstruction techniques.

5) UAS 251 - Drones Rapid Prototyping and System Integration

Credits and Contact Hours (lecture/laboratory): 2 credits, 1 lecture hour, 3 lab hours

Prerequisites: None

Course Description: In this hands-on course, students will have the chance to design, build, and fly UAV models to serve specific civilian and commercial applications. In this process, students will be able to build and construct UAV using CAD software (SolidWorks) and 3D printing technology in addition to CNC technology. In the second phase, students will be assisted in equipping the UAV with basic control units such as IMU and in finally testing and flying the UAVs.

Industry Advisory Council

The department of engineering and technology at Vaughn College has always recognized the value of external review of our curriculum to ensure that we are satisfying the needs of our constituents. The Industrial Advisory Committee (IAC) convenes every year, usually in the spring semester, and has met every year for the past 25 years. Since fall 2017, in addition to the annual technology meeting, we hold a fall meeting with our advisory members to discuss issues related to curriculum, laboratory development and program assessment. Also, through email communication, we continuously inform our advisory members and alumni about department activities, new program development, student professional engagement, and any issue related to accreditation and program assessment.

The IAC is comprised of representatives of industry, government agencies, academia and other segments of the profession who are able to advise the program on current industry trends and the latest state-of-art technologies that we can incorporate into our program. Their mission is to act as an advisory group to the program on specific academic issues and to act as a link between the program and its industry partners, providing an input to current and future industry needs for the program. Members of the IAC are comprised of a select group of representatives from Lockheed Martin, Pratt & Whitney GE, CYIENT, Dassault Systemes, Con Edison, Bakery Innovative Technology, Easy Aerial, FAA, CPI-Aerospace, Corning, COX and Company, SciMax Technologies, Micro Merchant Systems, Defense Contract Management Agency, Pavon Manufacturing Group, US Didactic, and Siemens. The close partnerships with these industrial companies allow our students to explore careers or internship opportunities with top engineering enterprises.

Some of the IAC members are past graduates and are deeply involved in the professional needs of the department. The Table below summarizes the membership of IAC, and after every annual meeting, minutes are produced along with an oral debriefing to the engineering department.

INDUSTRIAL ADVISORY COUNCIL COMMITTEE

Name	Company	Title	Member Since
Marvin Blackman	CARBON RKAYD Control & Systems Integration	Lead Onsite Service Specialist	2013
Robert Anderson	Bakery Innovative Technology	Control Engineer	2016
Oliver Scheel	U.S. Didactic	Director of Educational & Training Systems	2000
Michael A. Joseph, II	Corning, Incorporated	Sr. Project Engineer	2001
Michael Wroblewski	Stark Products	Manufacturing Engineer	2016
Raul Telles	Pratt & Whitney	Sr. Design Engineer	2012
Al Bunshaft	3DS, Dassault Systemes	SVP Global Affairs, Americas President, DS US Foundation	2017
Matthew Pearce	NASA	NASA Education Program Specialist	2015
Dr. Aparicio Carranza	CUNY-NYC College of Technology	Professor of Computer Engineering Technology	2011
John Pavon	Pavon Manufacturing Group	President	2007
Waseem Hussain	Union Crate	Co-Founder & VP	2017
Arya Ranasingh	Micro Merchant Systems	Computer Systems Analyst/ Sr. Team Lead	2009
Carlo Asaro	Lockheed Martin/Sikorsky Corp	Aircraft Electrical and Avionics	2015

		Engineer	
Nick Visciotti	Cyient Inc.	Technical Leader	2013
Jonathan Zubarriain	Cox & Company, Inc	Test Equipment Engineer	2018
Felipe I. Munoz	Lockheed Martin/Sikorsky Corp	Technical Lead- Platform Systems Integration (PSI)	2016
Manny Santana	Defense Contract Management Agency	Quality Assurance	2013
Rajdeep Singh	Lockheed Martin/Sikorsky Corp.	Deputy Chief Engineer	2010
Terry Jack	Lockheed Martin/Sikorsky Corp.	UAEW – Chief Engineer	2015
Hitesh Shah	Cyient Inc.	Business Unit Manager	2015
Beant Singh	Siemens	Project Engineer	2014
Diogenes Ramos	FAA	Executive Team Lead	2008
Omar Eldeebo	Lockheed Martin/Sikorsky Corp.	Harness Design Engineer Lean Six Sigma Green Belt	2016
Shiva Lall	FAA	Aerospace Engineer	2010
Robert Isoldi	CPI Aero	Manager of Manufacturing Operations	2016
Rich Brown	Lockheed Martin/Sikorsky Corp.	CH-53K/E Aftermarket Chief Engineer	2017

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 provide students with a greater appreciation for engineering education and expand their hands-on and career-building experiences. As a result of these internships, many of our graduates are currently working with these companies as new advisory members for our programs and assisting our current students in pursuing internships with these companies.

Faculty Professional Engagements and Workshop Participation

To improve the quality and effectiveness of instructional delivery and student learning, the engineering and technology department encourages faculty members to participate in conferences and workshops designed to enhance faculty 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 learning communities for NSF scholarship recipients.

During the calendar year 2018–2019, faculty in the engineering and technology department participated in the following professional engagements and workshops:

Hossein Rahemi

1. On Thursday, January 9, 2020, the department chair organized a **meeting with the Engineering and Technology Industry Advisory Board** to discuss new changes to EAC of ABET regarding Criterion 3, Student Outcomes, and Criterion 5, curriculum. In this meeting he updated advisory members with the department assessment process, self-study development, and preparation for the initial EAC-ABET accreditation of mechanical and electrical engineering programs. Dr. Rahemi thanked advisory members for their continuous support and input in every aspect of the department, student success, and the institution. His presentation covered items regarding changes to ABET's student outcomes and curriculum, as well as new "1 through 7" student outcomes assessment based on performance indicators.
2. On Saturday, February 1st 2020, the department chair supported Vaughn's UAV team in organizing and hosting its **2nd Tiny Whoop Race** in partnership with the Cradle of Aviation Museum for middle school and high school students.
3. In spring 2020, the Project Director submitted an annual progress report for the Title III STEM grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students" that includes information/updates on facilities, faculty and staff, and the development process of stackable manufacturing certificate programs, as well as on the process for developing the advanced manufacturing program.
4. On Friday, February 28, 2020, the department chair along with members of Vaughn's Robotics, UAV, and SWE clubs hosted its **sixth Annual VEX U College Regional Robotics Tournament**. A total of thirteen college teams participated at this event. The participant teams included Aquidneck Island Robotics (AIR), Johnson & Wales University (JWU1), South Dakota Schools of Mines and Technology (MINES), New Jersey Institute of Technology, New York Institute of Technology (NYIT), (NYIT2) and (NYIT3), Florida Polytechnic University (POLY1), Rutgers University (SKAR), University at Buffalo (UBR), Vaughn College of Aeronautics and Technology (VCAT) and (VCAT2), and

Worcester Polytechnic Institute (WPI). In this regional competition, Vaughn's robotics team won both first place "Robot Skills" and "Excellence" awards, which qualifies them to participate in the 2019 VEX U world championship.

5. On Saturday, February 29, 2020, the department chair, along with Vaughn's faculty and members of Robotics, UAV, and SWE clubs, hosted its **sixth high school state qualifier robotics competition**. A total of 58 regional high schools from Queens, Brooklyn, Bronx, Nassau, Suffolk and other NY counties attended the February VEX state qualifier at Vaughn College. Vaughn faculty members and staff served as the judges and Vaughn's robotics team served as manager, referees, announcers, and planner for this event. An alliance of Newfield High School and Centereach High School won the tournament championship, while a team from Newfield High School won the High School "Excellence" Award, Jericho High School won the "Design" Award and KG Computech won "Robot Skills" and Middle School "Excellence". Tournament champions, "Excellence" Award, "Design" Award and "Robot Skills" Winner qualified to participate in the New York State VEX Championship.
6. On Friday, March 6, 2020, the department chair along with faculty, lab techs, and STEM pathway Liaison hosted its **2nd annual STEM Day workshop** for community college students. The participants of Vaughn's STEM Day workshop were students and faculty from Passaic, Queensborough, Bergen community colleges. In the morning session, Vaughn's STEM Pathway Liaison and STEM project director, Dr. Hossein Rahemi, talked about Vaughn College's program offerings in engineering and engineering technology disciplines as well as student involvement in various STEM related clubs and professional activities. From 10:30 am to 11:30 pm, Avionics program coordinator, Prof. Mudassar Minhas, introduced audiences to the aircraft avionics system related to radar, navigation and communication. From 11:30 pm to 12:30 pm, Prof. Manuel Jesus, CNC and Additive manufacturing Curriculum developer, hosted a workshop at Vaughn's 3D Maker Space Center on 3D additive and subtractive manufacturing process using various 3D priming machines
7. On Saturday, March 6 2020, the department chair supported Vaughn College's Robotics team as they participated in and competed at the **West Virginia VEX U Robotics Regional Tournament**. A total of fourteen colleges and universities participated in the event, and Vaughn's robotics team finished **First** during qualifying matches and finished **2nd place** in "Robot Skills"
8. The department chair published the **Twelfth Annual Vaughn College Journal of Engineering and Technology (VCJET).** This journal includes annual department's activities, laboratories upgrade and development, faculty and student professional engagements, graduate success stories, industry tours, engineering seminar series, industry connection seminar series and student capstone design papers (April 2020).
9. On Friday, May 29, 2020, the Engineering and Technology department chair hosted its **Twelfth Annual Industry Advisory Meeting and Technology Day Conference**. In this virtual conference, Dr. Rahemi updated Advisory Council members with recent developments in the Engineering and Technology Department, such as: progress reports on program assessment and preparation for the 2020 initial EAC ABET accreditation of Mechanical and Electrical Engineering programs, HSI-STEM grant activities including the development process of stackable manufacturing certificate programs in CNC machining, Composite, 3D additive and subtractive manufacturing, and UAS that lead to a BS in advanced manufacturing program, the development process of manufacturing laboratories

(CNC machining, composite, additive manufacturing, automation, and UAS), and students' success in Robotics, UAV, and technical conferences. .

10. In spring 2020, the department chair, with assistance of the Academic Vice President, developed a **computer engineering** program proposal with concentration in cyber security and artificial intelligence tracks. The proposal has been submitted for the HSI-STEM title V grant funding, and in late summer the U.S. Department of Education approved funding for the implementation of this program.
11. From spring to fall 2020, the PD submitted a monthly progress report for the Title III STEM grant "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students" that includes information/updates on student engagement, facilities, faculty and staff, and the development process of the stackable manufacturing certificate programs as well as the process for developing the advanced manufacturing program.
12. In June, the Department chair submitted an article titled "**The Impact of Vaughn's Grant-Supported STEM Activities**" to HACU for publication. The. Article has been published in The Voice of Hispanic Higher Education, Volume 29, Number 2, Summer 2020
13. On Monday June 22nd, the engineering and technology department chair updated the board of trustees with department annual activities, assessment & preparation for the fall 2020 ABET virtual site visit, new stackable manufacturing certificate programs that lead to a BS in advanced manufacturing, student engagement (UAV, Robotics competitions, conference, and scholarly activities), industry connection seminar series, and other department related issues
14. In July 2020, the department chair **completed and uploaded two Self-Study reports** for the purpose of the initial EAC ABET accreditation of Mechanical and Electrical Engineering on the ABET website and all supporting materials were uploaded to a sharepoint for review by the ABET visiting team. From November 15 through November 17, EAC ABET conducted a Zoom virtual visit with Vaughn's faculty, students, alumni, senior administration, and industry advisory members, and during Tuesday's exit briefing they informed us that both programs are in compliance with all ABET criteria requirements. We expect to receive ABET's final accreditation statement for both of these programs in August 2021.
15. From July 27-31, 2020, the department chair, along with five students, participated in the LACCEI international virtual conference. The following Vaughn student papers, as listed below, were selected to compete among ten finalists for the student paper session, and two submitted papers were accepted for the poster session of LACCEI 2020 as well.
    - ✓ **"Modular Torque Wrench Extension with Heads-up Display"** by Atif Saeed, Juan Aguirre Rodrigues, and Juan Castano
    - ✓ **"Autonomous Medication Distributor Through Implementation of Bresenham's Line Algorithm"** by Brandon Duran, Diego Villegas, and Sebastian Valencia
    - ✓ **"Development of an Advanced Robotics Program for Middle and High School student"** by Ryan Tang Dan and Maharshi Patel.

    From 11 am to 1 pm on Tuesday July 28, three of our student team papers listed above were presented to the international conference audience, during the student paper session of LACCEI 2020. Vaughn's student team paper presentation by Atif Saeed, Juan Aguirre

Rodrigues, and Juan Castano covering the design, development, and manufacturing process of **Modular Torque Wrench Extension with Heads-up Display** was selected by judges as a **first place award recipients of 2020 LACEEI student paper session competition** Also, from 2:30 pm to 4:30 pm on Wednesday July 29, two of Vaughn's student team posters were selected for the LACCEI 2020 Virtual poster session competition. Vaughn's student poster by Brandon Duran, Diego Villegas, and Sebastian Valencia outlining their degree capstone project **"Autonomous Medication Distributor through Implementation of Bresenham's Line Algorithm"** was selected by judges as a recipient of the **First place award for the 2020 LACEEI student poster session competition.**

16. The Department chair, with input from the Aero Manufacturing curriculum Designer, developed a **UAS certificate** program, and in fall 2020 this certificate was submitted to the New York State Education Department (NYSED) for their review and approval.
17. On August 19, 2020 from 3 pm to 5 pm, the department chair and ME program coordinator attended the **ABET webinar** about documentation and preparation for the fall EAC-ABET team virtual visit for the purpose of initial accreditation of Vaughn's mechanical and electrical engineering programs. Currently, the department is uploading all necessary documentation to support compliance with the EAC-ABET criteria 1 through 8 to a sharepoint that can be reviewed and evaluated by the EAC program evaluators. The virtual Visit will take place from Nov. 15 through Nov. 17, 2020.
18. On August 28, the department chair, along with the 3D/CNC curriculum designer and Aero Manufacturing Curriculum developer, attended a **virtual orientation meeting** with Vaughn's new engineering and engineering technology students. In this meeting, Dr. Rahemi welcomed all new students and encouraged them to get involved with scholarly and hands-on STEM related activities that can enhance their career opportunities. Also, they provided advisement to students regarding curriculum and involvement in after class technical clubs and chapters of professional societies, and in participation in STEM outreach activities and conferences.
19. The department hair submitted the fifth annual progress report for both ME and EE programs including information/updates on: new/refurbished facilities, faculty and staff, and preparations for the 2020 ABET visit for the purpose of the initial EAC accreditation of ME and EE programs submitted to the NYSED on September 2020. A final report, with ABET's final statement, regarding accreditation actions for these two programs will be submitted to the NYSED in September 2021.
20. In September, the department chair and project director for the HSI-STEM grant wrote and submitted a **proposal for a supplemental award to support Virtual teaching** in challenging mathematics, physics, engineering, and engineering technology courses, and for acquiring laboratory hardware to facilitate lab software in the virtual environment, as well as to acquire state-of-the–art laboratory simulators that can be used to enhance student practical, hands-on laboratory knowledge and skills in the virtual environment. In September 25, we received approval for this supplemental award from the U.S. Department of Education..
21. On Thursday, September 17, 2020, the engineering and technology department held its **2nd Annual Curriculum and Career Advisement day** with students in engineering and engineering technology programs. The department chair, along with coordinators of Students Activities and Engagement, organized this virtual event to provide all engineering and engineering technology students with curriculum and career advisement. This virtual

event covered topics related to curriculum as well as to activities in which students should participate in order to enhance their career opportunities, while studying at Vaughn

22. The department chair organized and hosted the **6th annual manufacturing day conference** on Friday, October 30, 2020 (10 am to 2 pm) to celebrate the national Manufacturing Day. The guest speakers addressed the Vaughn community, faculty, and invited guests about current manufacturing innovation in the area of AM Journey to Production, Drone Manufacturing and ISO Manufacturing Standards, Digital Manufacturing and the IIOT: Success with a Single Platform, Industry 4.0-Part II, and additive manufacturing with consumer grade low cost 3D printers. In a parallel session, from 10 am to1 2:00 pm, Vaughn's Robotics, SWE, and UAV clubs organized and hosted virtual STEM workshops for high school students. These workshops covered Robotics and UAV design & autonomous programing as well as team preparation for the 2020-2021 VEX U Robotics and VFS-MAV competitions
23. From Oct 26 – 30, with the support of the HSI-STEM grant and assistance of the department chair, a group of eight engineering students from Vaughn College attended the **2020 Society of Hispanic Professional Engineers (SHPE) Virtual Conference**. Vaughn's students participated in Innovative challenge, and Extreme Engineering challenge as well as various professional development workshops that aimed to promote leadership and unity, and to expose them to the diverse career opportunities in the STEM fields. Also, Vaughn participated in the career fair session of the SHPE national conference, and Vaughn's SHPE chapter received a total of 12 interviews for both internship and full-time positions.
24. From November 2-13, with the support of HSI-STEM grant and assistance of the department chair, a group of ten Vaughn College's chapter of the Society of Women Engineers attended the **2020 Women Engineers Virtual Conference**. During the conference, students had the opportunity to attend leadership seminars and technology talks. In addition to attending seminars, SWE students attended the career fair, and they received interviews with industry leaders such as Johnson & Johnson, Stryker, Medtronic, Blue Origin, Northrop Grumman, Ball Corporation, Air Force Research Laboratory, Boston Technology, Siemens AG, Jacobs Engineering Group Inc., and Southwest Research Institute
25. From November 15 – 17, the department chair organized the **ABET virtual site visit** for the purpose of initial EAC accreditation of Vaughn's mechanical and electrical engineering programs. The ABET team reviewed the programs' self-study reports, all assessment and supporting documentation, as well as met Vaughn's faculty, students, alumni, senior administration, and industry advisory members through virtual Zoom meetings. During Tuesday's exit briefing, they informed us that both programs are in compliance with all ABET criteria requirements. We expect to receive ABET's final accreditation statement for both of these programs in August 2021.
26. On December 19th, 2020, with the support of HSI-STEM grant, five Vaughn Robotics teams participated in a remote VEX U skills tournament. During the skills challenge matches, Vaughn's team completed 3 programming and 3 driver attempts. Each attempt was 1 minute long. Out of a maximum score of 126, Vaughn's team scored 45 points in programming skill. In the driving skill, Vaughn's team scored 122 points out of a maximum score of 126 and with a total score of 167 for programming and manual (45 programming score + 122 driver score). **Currently, the VCAT team ranks 2 in World skills and ranks 1 in the United States.**
27. The PD, with input from the Aero Manufacturing curriculum Designer, developed a UAS certificate program, and in fall 2020 this certificate was submitted to the New York State

Education Department (NYSED). In January 2021, NYSED approved "*UAS Design, Application, and Operation"* to be offered at Vaughn College of Aeronautics and Technology. This certificate program has 5 courses and 13 credits. The following courses are part of this certificate program.

- UAS200 – Introduction to Unman Aerial Vehicles (Design, Operation, and system architecture for UAS), 3 Credits
- UAS220 - Drone Laws and Remote Pilot Certification**,** 3 Credits
- UAS231 - Introduction to Drone Aerodynamics, 3 credits (2 credits lecture & 1 credit Lab)
- UAS241 - Drone Application – Lan Surveying , 2 Credits (1 credit Lecture & 1 credit lab)
- UAS251 - Drones Rapid Prototyping and System Integration, 2 Credits (1 credit lecture & 1 credit lab)

28. On Saturday, Jan 16, 2021, the department chair, along with the Vaughn College Robotics team, hosted the Virtual VEX U College Regional Skills Robotics competition, and During the skills challenge matches, **Vaughn's team finished First in Robot Skills** with a total of 204 points. .
29. On Sunday, Jan 17, 2021, the PD, along with the Vaughn College Robotics team, hosted the Virtual High School VEX skills Robotics Tournament. A total of 9 regional high schools from Queens, Brooklyn, Bronx, Nassau, Suffolk and other NY counties attended the February VEX state qualifier at Vaughn College.
30. On Thursday, March 4, 2021, the HSI-STEM Project Director and the STEM Liaison hosted its 2nd annual Virtual STEM Day. For this virtual event, leaders of Vaughn's technical clubs and student chapters of professional societies (Robotics, NSBE, Rover, SHPE, SWE, and UAV) addressed the Vaughn community with a presentation about their annual professional activities, STEM outreach and workshops. In conclusion, Dr. Rahemi, thanked all leaders of Vaughn's technical clubs and of student chapters of professional societies for their excellent presentation, and he encouraged all participating students to join Vaughn technical clubs and to be involved in extra-curricular club activities. He emphasized how involvement in technical clubs and student chapters of professional societies further enhances leadership, teamwork, hands-on and other career-building skills. This involvement also promotes the cultivation of creative ideas, introduces one to innovations in the STEM fields and provides professional networking opportunities with engineering industries.
31. **Industry Connection and Engineering Seminar Series:** The department chair organized and invited several industry leaders as guest speakers for the fall and spring Industry Connection Seminar Series. The names, dates, and topics of presentation for those who accepted our invitation are as follows:
    - **An introduction to NASA and NASA Internship Opportunities:** on Tuesday, Feb 25, 2020, Mr. Matthew Pearce, National Aeronautics and Space Administration (NASA) education programs specialist and Ms. Rosalba Giarratano, Pathways Intern at the Goddard Institute for Space Studies, addressed the Vaughn community as part of College's Industry Connection Seminar series with a presentation on topics related to the space station opportunities for researchers, students, and educators, the NASA climate change research initiative (CCRI), the NASA Moon to

Mars mission and research benefits for humanity, and provided insight into current internship options for students, STEM engagement, and NASA's internship application and interview process.

- **An Overview of Summer Internship Programs with Stryker and Rolls-Royce:** On Tuesday, March 3, 2020, Ariel Ferrera, a senior student in mechanical engineering, and Jacqueline Oricchio, a senior mechatronic engineering student who participated in a summer internship program with Stryker and Rolls-Royce, addressed the Vaughn community about their summer internship projects. Ariel Ferrera's internship with Stryker was involved in designing and analyzing medical device tools such has reamers and oscillating saw blades to reduce thermal necrosis in orthopedic knee surgery, and Jacqueline Oricchio's internship program with Rolls-Royce consisted of taking 3d pdfs of engines and making the proper adjustments to them. These adjustments included putting components in their proper locations, adding textures to the models, and separating the engines into separate modules.
- **An introduction to NASA, NASA Goddard Space Flight Center, NASA Goddard Institute for Space Studies and NASA Internship Opportunities:** on Thursday, Feb 11, 2021, Mr. Matthew Pearce, National Aeronautics and Space Administration (NASA) education programs specialist and Ms. Rosalba Giarratano, Pathways Intern at the Goddard Institute for Space Studies, addressed the Vaughn community as part of the College's Industry Connection Seminar series. For this Microsoft Teams Virtual event, both Ms. Rosalba Giarratano and Mr. Pearce's presentation covered topics related to an overview of NASA, NASA Goddard Institute for Space Studies, NASA STEM Workforce Challenges, and they talked about all available STEM Internships, Fellowships, and other career opportunities with NASA and NASA's internship application and interview process.
- **Power System Integration for Aerospace Industry:** On Friday February 19, 2021, Mr. Carlo Asaro, a senior Aircraft Avionics Systems Engineer for Sikorsky, addressed the Vaughn community as part of the College's Industry Connection Seminar series. For this virtual event seminar, Mr. Asaro talked about topics related to high horse power motor, PLC, high power cables conductors, electronics conduit design and manufacturing processes within the aerospace industry (Attachment#2-Power System Integration for Aerospace Industry)..
- **Celebrating Black History and Women's History months with Engineer and Astronaut Stephanie Wilson, March 9, 2021:** On Tuesday, March 9th from 10 to 11 am, Vaughn's students, faculty, and Staff in observance of Black History and Women's History months, participated in a virtual fireside chat with engineer and NASA astronaut Stephanie Wilson to celebrate accomplishments of distinguished African American Engineers and Astronauts. This special virtual meeting was held by NASA to promote STEM in education. Stephanie Wilson graciously shared her career path as an African American Woman involved in a STEM career. Specifically, she shared insight regarding her role as an astronaut with NASA during the Shuttle Program and construction of the International Space Station. First and foremost, Stephanie made a point to share that she was an aerospace engineer who worked hard to lay the foundations that eventually brought her to a successful career as a leading astronaut.

- **Electrical Safety and Consideration:** On Tuesday, March 23, 2021, Mr. Carlo Asaro, a senior Aircraft Avionics Systems Engineer for Sikorsky and an adjunct faculty member at Vaughn College, addressed the Vaughn community on the topic of Electrical Safety Considerations, as part of the College's Virtual Industry Connection Seminar series. The overall topic of the presentation was safety first. The serious nature of this topic was addressed through discussion of tragic workplace accidents related to servicing motors accidentally left in a powered-on state. Personal electrical safety equipment such as probes, high voltage resistant gloves, and foot pads were shown as effective measures against fatal injuries.
- **Update on new FAA drone Rules that go into effect April 2021:** On Thursday, April 15 from 11 am to 12 pm, as part of the College's industry connection seminar series**,** Ms. Loretta Alkalay, an aviation attorney specializing in issues related to compliance with federal aviation regulations including drone rules, who is also an adjunct professor at Vaughn College, updated the Vaughn community on new FAA drone rules that go into effect April 2021, including the operations over people rule and the remote ID rule.

Amir Elzawawy

1. 2019/2020 academic year, in preparation for the ABET visit, coordinated with the engineering and technology department the following tasks:
   - ✓ Assisted the department with the ABET-EAC and ETAC teams visit on October 2019.
   - ✓ Completed outcome assessment reports for Heat Transfer and Capstone Projects.
   - ✓ Assisted the department chair with the ME program assessment, in preparation for the fall 2020 initial EAC ABET accreditation.
   - ✓ Assisted the department in organizing the virtual display room in preparation for the fall 2020 virtual visit, for the initial EAC ABET accreditation of the ME program.
2. Attended the Annual COMSOL Multiphysics Conference and advised a team of two students on a paper entitled "Design and Fabrication of Small-Scale Supersonic Wind Tunnel". The project was presented in the CFD-FSI oral presentation session as well as to the Poster Session Presentation on Thursday, Oct. 3rd. Boston, MA, October 2 – 4, 2019.
3. Attended, with Vaughn's team, the Robotic Club VEX International Competition at Rivera Maya University, Mexico on December 12-14, 2019.
4. Developed the outline of the courses for the Unmanned Aerial Systems (UAS) Certificate program. The engineering department developed and submitted the UAS certificate program to NYSED for approval.
5. Established the UAS laboratory at Vaughn College. The UAS lab is currently equipped with an Autonomous Vehicle Research Studio, two QDrones, two Q-Aero workstations and all supporting software.
6. July 27 to 29, attended the following IEEE Virtual Training sessions regarding remote teaching strategies:
   - ✓ "Ditching the Traditional College Lecture in Remote Instruction."
   - ✓ "Managing Remote Student Teams."
   - ✓ "Student and Data Privacy when Offering Remote Instruction."
7. Attended the AIAA 2020 Regional Leadership Conference, a series of events planned during the month of August:

- ✓ August 1st, AIAA RLC: Region I What's My Role? Officer Roles & Responsibilities
- ✓ August 8th, AIAA RLC - Exploring Outreach & Areas of Interest
- ✓ August 12th, AIAA RLC - Unpacking Your Section Toolkit
- ✓ August 20th, AIAA RLC - Embracing Social Distancing & Going Online
- ✓ August 27th, AIAA RLC - Regional Student Paper Conference 101

8. July 2020, Project director of the Collegiate Science and Technology Entry Program (CSTEP) funded by NYSED.
9. August 19th attended ABET institutional representative webinar.
10. Served in the faculty senate for the academic year 2019/2020.

Ghania Benbelkacem

1. Developed and hosted two Fundamentals of Engineering Workshops as part of the CSTEP – College Science Technology Program, to support Vauhgn student's success, Spring 21.
2. Participated in ABET initial accreditation for ME and EE programs, including preparation of course and assessment materials, and met with ABET's program evaluator for ME program, November 2020.
3. Served as a member of a subcommittee to work on new outreach in terms of appealing to broader industry partners, in order to open new opportunities for Vaughn graduates, since November 2020.
4. Attended Aviation Week Network, entitled "How will research into sustainable aviation shape the aircraft of the 2030s and beyond? ". Discussions were about what implications will hybrid-electric, hydrogen propulsion and cutting-edge aerodynamics hold for Airbus, Boeing, Embraer, regional aircraft manufacturers and suppliers? , December 11th, 2020.
5. Participated at Vaughn's 6th Annual Manufacturing Day, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing. October 30th, 2020.
6. Attended four IEEE continuing education webinars by Penn State's engineering department. These webinars addressed eLearning to support distance learning. The content focused on how to organize events, effective teaching, and STEM related activities, July, 2020. The four webinar titles are:
    - Ditching the Traditional College Lecture in Remote Instruction.
    - Making Labs Effective with Remote Learning.
    - Managing Remote Students Team.
    - Student Assessment for Remote Delivery.
7. Attended "Communication across cultures" course offered by Linkedin learning, July, 2020.
8. Participated at Vaughn's 12th Annual Vaughn College Technology Day Conference, a one-day event and presentation of department annual activities, presentation of technical clubs annual activities & accomplishment, and presentation of students' capstone degree projects, May 29, 2020.
9. Participated in the "Learning Community" and supervised teams on Community Projects, Spring - 2020.
10. Advised students on Capstone degree projects, Spring and Fall 2020.
11. Attended all of Vaughn's spring and fall 2020 Industry Connection Seminar Series, and Engineering Seminar Series.

12. Processed image analysis on single and couple Zebra fish behaviors in water flow (since summer 2020) using software developed at Tandon school of Engineering. The aim is to try to understand Rheotaxi behavior of those species..
13. Attended Research and Teaching Webinars offered by NYU – Tandon School of Engineering and it's partners, 2020.
14. Involved with Vaughn college clubs: Society of Women Engineers, Engineers Without Borders.
15. Member of American Society of Rheology, ASME and ASAA. Reviewer for Journal of Rheology.

Shouling He

1. Served as a Mechatronic Engineering (MCE) Program Coordinator in 2020 completed the following tasks
   (1) Wrote the assessments of Mechatronic's capstone degree projects (MCE409) with the design consideration of social, economic, etc. factors in response to the ABET Board questions to resolve the shortcoming concerns regarding design outcome.
   (2) Continually improved the Mechatronic Engineering curriculum by updating the courses, MCE310 Intro. to Linux and ROS (Robot Operation System), MCE410/MCE410L Mechatronics I and Lab, MCE420/MCE420L Mechatronics II and Lab, MCE355 Robotic Mechanics and Control, MCE401 Pre-Capstone Degree Project, writing the updated course syllabi and course descriptions for the Vaughn Catalog.
   (3) Wrote meeting minutes for the continual improvement of Mechatronic Engineering program;
   (4) Evaluated transfer students' transcripts and advised Mechatronics students in their career goals, as well as course and elective course selections.
2. Served as a main faculty member of Electrical Engineering (ELE) program, provided the course syllabi, FCARs, as well as course samples, with the required outcomes samples based on performance indicators for the courses such as, ELE409 Capstone Degree Project, ELE326/ELE326L Microprocessors, ELE450/ELE450L Data Acquisition and Applied Control System Design, ELE355/ ELE355L, Advanced Microprocessors, ELE230/ELE230L Digital Systems Design, MCE420/MCE420L Autonomous Mobile Robots (Elective).
3. Participated in the 2020 ABET Board Visiting Meeting for the Electrical Engineering program, provided evidence for the ABET requirements of the capstone degree projects and helped the department to receive the ABET accreditation for the Electrical Engineering program.
4. Worked as the advisor for the first group of Electrical Engineering capstone degree projects and the student research project presentations at the 2020 VCAT Tech Day Conference and helped students to develop the research paper for publication in the 2020 VCJET.
5. Wrote the application for NSF Mentor-Connect, a highly regarded mentoring program for faculty preparation of competitive proposals, for the National Science Foundation Advanced Technological Education (NSF/ATE) Program, and accepted fellowship in NSF Mentor-Connect (2020-2021).
6. Participated in the Sixth Manufacturing Day Conference held on October 30, 2020 and discussed the presentations in the areas of industry 4.0, drone manufacturing, and ISO standards, digital and additive manufacturing, and aerospace innovation in additive manufacturing.

7. Completed online course "Deep Learning Essential" with the grade of A (+92/100), taught by the team of Dr. Yoshua Benjio, the recipient of the 2018 ACM A.M. Turing Award, "the Nobel Prize of Computing", June 2 - July 20, 2020.
8. Completed five IEEE Continuing Education Units with Certificate of Completion (after test), July 27 - July 31, 2020.
   (1) Ditching the Traditional College Lecture in Remote Instructions
   (2) Making Lab Effective with Remote Learning
   (3) Managing Remote Student Teams
   (4) Student Assessments for Remote Delivery
   (5) Student and Data Privacy when Offering Remote Instruction
9. Attended the 10th IEEE Integrated STEM Education Conference, "Bring Artificial Intelligence into the Real World", held by Princeton University, August 1, 2020.
10. Developed new course materials for MCE410/MCE410L, Industrial Manufacturing Automation and Laboratory, to use new Siemens Programmable Logic Controller (PLC) S7-1200 and new program design environment TIA PORTAL, PLC Simulator (PLCSIM) as well as new device Human Machine Interface (HMI).
11. Developed new laboratory materials for ELE230L Digital Systems Design Lab to use Very high-speed Integrated Hardware Description Language (VHDL) for the updated Xilinx FPGA (Field Programmable Gate Array) board, new laboratory materials for ELE326L Microprocessors to use new compiler XC8 and 4-line LCD (Liquid Crystal Display) Module.
12. Worked as a technical judge for VEX IQ Robotics Competition held on February 22, 2020 at Vaughn College, and evaluated the performance of elementary and middle school students from more than 40 teams and 18 schools.
13. Served as a faculty performance evaluator to conduct course observation and write recommendations and reviews for the promotion and tenure of faculty members, March - June 2020.
14. Wrote 9 recommendation letters for Mechatronic and Electrical engineering students and alumni for job applications, graduate schools, and scholarships.

Yougashwar Boohoo

1. Advised students of the SHPE club at Vaughn College.
2. Completed an online certificate course 'Introduction to D2L' in April, 2020.
3. Completed an online certificate course 'How to Project Vocal Confidence' on May 6, 2020.
4. Completed an online certificate course 'Learning to Teach Online' on May 9, 2020.
5. Completed an online certificate course 'Managing your Anxiety while Presenting' on June 23, 2020.
6. Assisted the department chair with laboratory development and courses for the composite certificate program.
7. Completed an online certificate course "Teaching Online: Synchronous Classes" on June 25, 2020.
8. Completed course and program level assessment for courses in the Mechanical Engineering Technology (MET) Program in preparation for the fall 2019 ABET site visit.
9. Participated in the initial EAC-ABET program accreditation of the Mechanical Engineering program, provided course samples, student outcome samples, and assessment materials for the purpose of fall 2020 EAC-ABET accreditation of this program.

10. Worked closely with department chairman and members of the Vaughn community in preparation for the ME program ABET virtual visit, developed and provided a prerecorded video of mechanical testing lab as display material for the ABET visiting team.
11. Attended the Twelfth Vaughn College Annual Technology Day Conference, May 29, 2020.

Douglas Jahnke

1. Advisor for the Society of Automotive Engineers (SAE) chapter at Vaughn College. 2018 – present
2. Member of ASME – The American Society of Mechanical Engineers, New York, NY, 2010 – present
3. Served on Student Retention Committee to develop ideas to improve student retention at Vaughn College. 2018 – present
4. Served as co-chair of Marketing and Enrollment working group for Vaughn College's strategic planning initiative. 2018 – present
5. Attended "Advanced Composite Structures: Fabrication & Damage Repair-Phase 1", Abaris Training, Reno, Nevada, January 7-11, 2019
6. Attended "Formula SAE Michigan" with the Vaughn SAE club, Michigan International Speedway, Brooklyn, MI, May 8-11, 2019
7. Attended "By Air, By Land, By Sea: Composites Get You There" two-day workshop by Composites One and the Closed Mold Alliance in partnership with IACMI – The Composites Institute, Plainview, NY, June 11-12, 2019
8. Participated in preparation of grant proposal for NSF S-STEM proposal, Increasing Student Enrollment and Achievement in Engineering and Engineering Technology, submitted March 2019
9. Participated in ABET program accreditation review, including preparation of course and assessment materials, for Fall 2019 ABET visit
10. Attended Industry Connection Seminar Series, Vaughn College, Flushing, NY, 2019 and 2020.
11. Attended 5th Annual Manufacturing Day Conference, Vaughn College, Flushing, NY, November 1, 2019
12. Publication: Yildiz, S., Andreopoulos, Y., Jensen, R. E., Shaffren, D., Jahnke, D., and Delale, F., 2019, "Characterization of Adhesively Bonded Aluminum Plates Subjected to Shock-Wave Loading," International Journal of Impact Engineering, 127, pp. 86–99.
13. Participated in first-time ABET program accreditation of the Mechanical Engineering program, including preparation of course and assessment materials, for Fall 2020 ABET visit
14. Attended Annual Technology Day Conference, Vaughn College, Flushing, NY, May 29, 2020
15. Attended 6th Annual Manufacturing Day Conference, Vaughn College, Flushing, NY, October 30, 2020
16. Completed "Ditching the Traditional College Lecture in Remote Instruction," IEEE Effective Remote Instruction: Reimagining the Engineering Student Experience webinar, July 27, 2020
17. Completed "Making Labs Effective with Remote Learning," IEEE Effective Remote Instruction: Reimagining the Engineering Student Experience webinar, July 28, 2020
18. Completed "Managing Remote Student Teams," IEEE Effective Remote Instruction: Reimagining the Engineering Student Experience webinar, July 29, 2020

19. Completed "Student Assessments for Remote Delivery," IEEE Effective Remote Instruction: Reimagining the Engineering Student Experience webinar, July 30, 2020
20. Completed "Student and Data Privacy when Offering Remote Instruction," IEEE Effective Remote Instruction: Reimagining the Engineering Student Experience webinar, July 31, 2020

Harrison Carranza

1. Presented paper presented at Proceedings of the 7th International Conference of Control Systems, and Robotics (CDSR'20), November 11, 2020, Ottawa, Canada via Zoom titled "Wireless Sensor Network Security for Smart Home IoT Systems", alongside co-authors Aparicio Carranza, Xiaolin Chen, Heesang Kim, Casimer DeCusatis.
2. Attended 12th Technology Day Virtual Conference, Vaughn College, a one-day event and presentation of annual activities from departments and technical clubs, accomplishments and presentations of students' capstone degree projects and networking with industrial leaders, May 29, 2020.
3. Attended 6th Manufacturing Day Virtual Conference, Vaughn College, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing, October 30, 2020.
4. Modified course material for EET210-Electronic Laboratory Practices because of COVID19 crisis. This hands-on course was to be held online until further notice. The task was to come up with laboratory experiments as well as lectures that could supplement those labs to fulfill course requirements.
5. Developed course material for AVT235-Aircraft Navigation Systems. Acquired books for lecture use as well as implemented the use of electronic lab experiments using op-amps. During the COVID19 crisis, heavily used Multisim to fulfill course requirements.
6. Developed course material for AVT346-Power and Distribution Systems by using electronic lab manuals as well as online resources to create labs for the students. Lab experiments were done using Multisim to fulfill course requirements due to COVID19.
7. Developed course material for AVT453-Traffic Collision Avoidance Systems, taught online through Zoom in response to the COVID19 crisis. This includes creating lecture notes, acquiring books and resources for course use. As an alternative to physical labs, video simulations were demonstrated since no practical work could be done on campus due to COVID19 crisis.
8. During Summer 2020 Session 1, worked one-on-one with a student, Keith Pustam to help develop the course EET115-Electrical Circuits I to use as a reference for future sections. With the use of Multisim, we were able to conduct 10 laboratory experiments thru virtual mode due to the COVID19 crisis. As a result, the work presented by the student along with my advising, the material could be used a role model for future students in the assistance of learning how to write lab reports as well as acquire knowledge of data acquisition.
9. During Summer 2020 Session 2, worked with STEP Program students by teaching them Robotics using Arduino, Basic programming using Python, computer digital logic as well as number systems, and a basic overview of cybersecurity plus the world of ethical hacking. This was the first time that cybersecurity was offered by the program. My task was to develop course material for the students to acquire the basic necessary knowledge of computers to give them the incentive to pursue a career in this field.

10. Actively mentored and tutored students, through Zoom or other forms of communication, on and off my office hours to provide them assistance with courses.
11. Attended Open House during Fall 2019 to assist faculty in providing information to potential future incoming students.

Mohammed Benalla

1. Reviewer and Chair of Biomechanics session, thirty-six Southern Biomedical Engineering Conference, New Orleans LA, March 6-8, 2020
2. Developed Faculty Course Assessment Reports, FCARs, in preparation for the initial fall 2020 EAC-ABET accreditation of EE programs.
3. Prepared ABET teaching materials (PPT, HWs, Exams, Lab reports and finals) along with the outcome objectives of the following courses:
   - EGR380, Engineering Project Management
   - ELE117, DC/AC Circuits
   - ELE118, ELECTRIC CIRCUITS II
   - ELE220, Electronic Circuits Lecture / Lab
   - ELE325, Electric Machines
   - ELE322, Signals & Systems
   - ELE330, Principles of Communication Systems
   - ELE401, EE Pre-Capstone Project
4. Attended 12th Technology Day Virtual Conference, Vaughn College, a one-day event and presentation of annual activities from departments and technical clubs, accomplishments and presentations of students' capstone degree projects and networking with industrial leaders, May 29, 2020.
5. Attended 6th Manufacturing Day Virtual Conference, Vaughn College, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing, October 30, 2020.
6. Attended open houses and Graduation for fall and spring of the academic year 2019 - 2020
7. Developed new elective course "Biomedical Engineering Instrumentation - ELE456"
8. Advisor for students' oral presentation in *36th Southern Biomedical Engineering Conference, New Orleans, LA, March 6 - 8, 2020.*
   - ✓ "Haptic Thermal Feedback Prosthetic Brain Controlled Arm", *Atif Said, Ryan Bobby Tang Dan and Mohammed Benalla, Won 2nd price.*
   - ✓ "Non-invasive Glucose Monitoring System with Server Link", *Ryan Bobby Tang Dan, Atif Said and Mohammed Benalla*
   - ✓ "Automated Medicine Dispenser", *Sebastian Valencia, Diego Villegas, and Mohammed Benalla*
9. Advisor for students' papers publication in *Biomedical sciences Journal, January 2020, Volume 56(1)*:
   - ✓ "Automated Medicine Dispenser", *Sebastian Valencia, Diego Villegas, and Mohammed Benalla*
   - ✓ "Haptic Thermal Feedback Prosthetic Brain Controlled Arm", *Atif Said and Mohammed Benalla*
10. Advised and mentored different teams of students to develop two research journal papers for VCJET 2019. The projects were presented in the afternoon session of 11th Annual

Vaughn College Technology Day Conference, April 2019 and won the second and third places.

11. Reviewer and Chair of Biomechanics session, 35th Southern Biomedical Engineering Conference, Hattiesburg, MS, February 22-24, 2019

Miguel A. Bustamante

1. On March 31, 2021, attended a webinar hosted by Red Hat Academy for all RHA faculty and instructors. The topic of discussion was "Hear why Red Hat Certifications are important" from a former hiring manager and current Red Hat Consultants" The subject was the importance of cybersecurity within the computer engineering field.
2. Seminar introduction to MATLAB February 23, 2021, in this session, I learned how MATLAB can be used to visualize and analyze data, perform numerical computations, and develop algorithms. Through live demonstrations and examples, we saw how MATLAB can help faculty and students to become more effective in mathematical models. The Highlights of the seminar included:
    - Accessing data from many sources (files, other software, hardware, etc.)
    - Using interactive tools for iterative exploration, design, and problem solving
    - Automating and capturing your work in easy-to-write interactive scripts and programs
    - Sharing your results with others by automatically creating reports
    - Building and deploying interactive applications
    - Performing these workflows from anywhere, with MATLAB Online
3. Advised and mentored multiple teams of students to develop research journal papers for VCJET 2020.
4. Attended the 6th Manufacturing Day Virtual Conference, Vaughn College, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing, October 30, 2020.
5. Attended Mentor-Connect Cohort 8 conference, a team composed of Dr. Miguel Bustamante, Professor Rodney Dash, and Grant manager Natasha Waldron, who participated in the Technical Assistance and Grant writing workshop hosted in New Orleans, January 28 to the 31 2020. The objectives for this workshop were to engage participants in the ATE community and prepare college teams and their accompanying grant writers and/or administrators to initiate a fundable NSF ATE grant proposal. This Mentor-Connect was entered as a competition, and our team from Vaughn College was selected to participate on this journey.
6. During the summer 2019, Dr. Bustamante advised a high school student on developing water testing devices using Arduino and water sensors. Student Oling Grayson worked during the summer 2019 and part of the Fall 2019 and Spring 2020 (zoom) on Optical sensors and microprocessors. He was part of the summer program where students collaborate on research to provide a better and faster way to detect water contaminants. Grayson did complete a total of 39 hours working with me and the college student research team. He is currently finishing a working model using Fusion 360.
7. On November 7 – 10, 2019, a group of four students: Amanda Camacho, Kiki Kuonqui, Michael Boller and Johann Cole from Engineers-Without-Boarders Vaughn Chapter and Faculty adviser Dr. Miguel Bustamante from Vaughn College attended the annual EWB-USA conference hosted in Pittsburgh, PA.
8. On July 22 to the 25, 2019 a group of Faculty and Staff members, Dr. Miguel Bustamante

Assistant Professor of Electrical Engineering, Professor Dash Rodney from Arts and Science Department, Dr. Edgar Troudt Associate Vice-president of Academics Affairs, Natasha Waldron Grants Manager and Lauren Cajade, Assistant Director Higher Education Opportunity Program (HEOP) from Vaughn College attended the HI-TEC conference hosted in St. Louis, Missouri. HI-TEC is a national conference on advanced technological education where secondary and postsecondary educators, counselors, industry professionals, trade organizations, and technicians can update their knowledge and skills. HI-TEC is produced by the National Science Foundation Advanced Technological Education (NSF ATE) community.

9. Dr. Miguel Bustamante and Dr. Shouling He, assistant professor and associate professor in Vaughn's engineering and technology department attended the Educational Workshop, Project Catalyst – How to Engineer Engineering Education, held by Bucknell University during July 17-19, 2019. The workshop explored how to use active and cooperative learning to efficiently improve professors' teaching performance as well as how to assess students' learning outcomes. Forty-six faculties from different universities, such as John Hopkins University, University of Pennsylvania, Pennsylvania State University, Drexel University, as well as New Jersey Institute of Technology, joined the workshop.
10. On April 9, 2019, Dr. Miguel Bustamante, Assistant professor of Engineering and Technology department at Vaughn College of Aeronautics and twelve Learning Community students from Vaughn College's Engineering and Technology Department visited the Brookhaven National Laboratory (BNL) in Long Island, New York. The tour was organized by Jessica Caron, Director of Career services at Vaugh College which included visits to the Superconducting Magnet Division (SMD) and Central Chilled Water Facility.
11. Participated in the Engineering Without Borders (EWB-USA)-Water testing Research Project trip to Kigali, Rwanda Feb18-28, 2019. The goal of this project is to design and implement a potable water system in a town of 1,500. The project will depend on the findings of this first trip. Recommendations will be given on a future second trip to the Kibingo village to provide a safe potable water system for its residents.
12. EWB-USA Water testing workshop-Jan 19, 2019. One day training on how to take measurements of water contaminants and properly record data obtained from the optical sensors. There was also biological testing for e-coli contaminants on water sources, and we also learned how to avoid cross contamination of samples.

Manuel Jesus

1. Advised students on degree project tasks related to additive manufacturing, 3D Scanning, and CAD related tasks. (Ongoing)
2. Participated and co-hosted Vaughn's 13th Annual Technology Day Conference, a one-day event and presentation of department annual activities, presentation of technical clubs, annual activities, accomplishments, and presentation of students' capstone degree projects as well as networking with industrial leaders. May 29th, 2020.
3. On Thursday September 17, 2020, attended the **2nd Annual Curriculum and Career Advisement day** with students in engineering and engineering technology programs. This virtual meeting discussion covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn.

4. Participated and developed virtual online content for the Spring 2020 and Fall 2020 Virtual Open House Sessions.(Spring and Fall 2020)
5. Co-hosted Virtual Manufacturing Day Leadership Session Conference. Presentations were given by industry experts and successful alumni for the purpose of sharing inspirational success stories, technical expertise and mastery in their field, student engagement, and networking. The conference centered around cutting-edge use of additive manufacturing and industry 4.0. Prof Jesus sought out presenters from General Electric, Proto Labs, and Dassault to participate in this annual event, and he delivered a presentation on low-cost high-quality consumer grade 3D printing options for students operating on an extremely restrained budget, October 30, 2020
6. Contributed activity reports related to ongoing Virtual student engagement events for use in the Vaughn College Journal of Engineering Technology.(Ongoing)
7. Co-hosted several sessions of virtual engineering seminar series, spring 2021.
8. Dassualt CATIA 3DExperience Onboarding Training Session for Deployment in Education. Assisted in hardware and software compatibility testing and transition from onsite educational software to online CATIA V5 deployment. (Virtual Sessions), April 2020
9. Training - Tooling U online CNC courses from Society of Mechanical Engineers (Ongoing)
10. Training - CAM Instructor CNC for Instructors Course. Toronto, Ontario (Ongoing)
11. Training - Unreal Engine 4 Virtual Reality Prop and Environment Content Creation Online Workshop, Vertex School Summer 2020

Khalid Mouaouya

1. Attended 12th Technology Day Virtual Conference, Vaughn College, a one-day event and presentation of annual activities from departments and technical clubs, accomplishments and presentations of students' capstone degree projects and networking with industrial leaders, May 29, 2020.
2. Attended 6th Manufacturing Day Virtual Conference, Vaughn College, a one-day event for networking with industrial leaders in engineering, aviation, and manufacturing, October 30, 2020.
3. Participated in ABET program accreditation review, including preparation of course and assessment materials, for Fall 2019 ABET visit
4. Participated and attended 2020 LACCEI virtual international engineering conference, July 27-31, 2020.
5. On Thursday September 17, 2020, attended the **2nd Annual Curriculum and Career Advisement day** with students in engineering and engineering technology programs. This virtual meeting discussion covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn. In this roundtable gathering, we discussed several career strategies for obtaining a successful career in STEM fields.
6. Participated in all Vaughn's spring and fall 2020-2021 Industry Connection Seminar Series, and Engineering Seminar Series.
7. Participated with Vaughn's Robotics team in the Signature Mexico's VEX U Reeduca Robotics Challenge competition in the Univeredad Technologica De La Riveria Maya, Cancun, Mexico, December 12-14, 2019.
8. Participated at Vaughn's 11th Annual Vaughn College Technology Day Conference, a one-

day event and presentation of department annual activities, presentation of technical clubs annual activities & accomplishment, and presentation of students' capstone degree projects as well as networking with industrial leaders, April 19, 2019.

Jonathan Sypeck

1. Advised and mentored several Associates Degree students in their final Degree Project, relating to the fields of Conceptual Aircraft Design and Flow Simulation using SolidWorks.
2. Attended 12th Technology Day Virtual Conference, Vaughn College, a one-day event and presentation of annual activities from departments and technical clubs, accomplishments and presentations of students' capstone degree projects and networking with industrial leaders, May 29, 2020.
3. Helped conduct Virtual Open Houses for undergraduate students at Vaughn College during spring and fall 2020 and presented engineering and engineering technology program offerings.
4. Conducted several hands-on training sessions in D2L for faculty, specifically in the use of synchronous learning with its built-in Virtual Classroom feature. This was part of Vaughn College's response to the COVID-19 crisis in the Spring of 2020.
5. Continued to work one-on-one with faculty from both the academic and Aviation Training Institute sides of the College to maintain their online presence and synchronous lectures during the COVID-19 crisis in the Spring of 2020.
6. Attended IEEE "Effective Remote Instruction: Reimagining the Engineering Student Experience" Webinars over the course of five days in Summer 2020 to gain extensive knowledge on how to pivot traditional Engineering lecture and lab teaching techniques to meet the virtual-environment requirements of today's COVID-19 world.
7. Attended ASEE "Thinking Outside the Box: Alternative Assessment Methods" Webinar in Fall 2020 to gain valuable information regarding how to assess students through virtual learning.
8. Attended ASEE "How Boise State University Provides Engineering Students with Remote Access to Applications & Desktops" Webinar in Fall 2020 to gain important information regarding how to migrate traditional Engineering software from on-campus offerings to virtual desktops and web-apps.
9. On Thursday September 17, 2020, attended the **2nd Annual Curriculum and Career Advisement day** with students in engineering and engineering technology programs. This virtual meeting discussion covered activities in which students should participate in order to enhance their career opportunities while studying at Vaughn. In this virtual gathering, we discussed several career strategies for obtaining a successful career in STEM fields.
10. Participated in all Vaughn's spring and fall 2020-2021 Industry Connection Seminar Series, and Engineering Seminar Series.

Graduate Success Stories

In order to prepare students for the growing demands of today's technology and to aid them in their future careers, the Engineering and Technology Department at Vaughn College adopted a set of in-class and out-of-class academic activities reflective of ongoing technological change. These activities are designed to instill in students an awareness of the importance of lifelong learning in meeting the challenges in their future professions.

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

Ariel A. Ferrera Class of 2020
Space and Weapons Mechanical Engineer
Marotta Controls, Montville NJ
Bachelor's Degree in Mechanical Engineering, 2020

I recollect the first day I took the New York City subway to pursue what is now my greatest passion, engineering. Taking up Mechanical Engineering in my undergraduate education stems from a deep desire to learn physics, mathematics and science, in order to give back to society. I was born on a small farm in Cuba, and it was through sheer luck that I was brought to the United States. The high school I graduated from provided scant STEM education, and I did not yet realize what was entailed in engineering.

When I commenced my studies here at Vaughn in the Mechanical Engineering Program, my commute involved many NJ transit tickets and waiting in line on cold winter mornings for the M60 bus. I worked multiple part-time jobs, and endured a total commute from NJ of just under four hours daily. From the minute I walked on campus, a future in engineering seemed plausible, since I encountered Dr. Rahemi, Dr. Elzawawy, Dr. Addabbo, Dr. Budhoo, and Dr. Lavergne who were always there for me and my fellow classmates. The faculty at Vaughn went in depth on every subject and provided me with critical life lessons that have made me prosperous along the way. During my undergraduate studies, I was able to intern two years in a row in the medical device industry designing implants and orthopaedic tooling at Stryker. Vaughn's engineering seminars sanctioned me to become a co-op research assistant at NASA's Marshall Space Flight Center analyzing desultory vibration loading for space hardware utilization.

After completion of my undergraduate program here, I transitioned to the private space industry. At Marotta Controls, we engender flight qualified engineered propulsion controls utilized in stage separation, fin control actuation engine controls, landing leg deployment, pressurization systems, posture control systems, and propellant systems. Our products have played a critical role in the earliest days of manned spaceflight, from the fuel control valves on the Saturn rocket to propulsion systems for the Lunar Module ascent and descent engine. My role consists of designing and solving kineticism and flow control quandaries – and to expeditiously engender ingenious and practical daily solutions for space system customer applications. My advice to students and is to stay consistent, set your goals, and never be afraid to ask *why*. Your motivation determines how much you are inclined to do, but your discipline determines how well you achieve your goals.

Hector Sabillon, Class of 2019
Engineering Development Program, John Deere
BS in Mechatronics Engineering, 2019

I have been a witness to the unexpected turns life can hold. Sometimes, even while everything may seem to be going as planned, the unexpected in life challenges us to ignite our core, testing our strength and resilience. Life ignited my core, starting in 2015 – preparing me for a stellar launch in 2019 when I obtained my degree from Vaughn College of Aeronautics and Technology.

My curiosity for understanding how things work was sparked as a child. From repairing my mom's kitchen appliances to leading science fair projects in high school, I have always had a keen inclination towards science and physics. Since I was born in Honduras, however, there were limited opportunities to continue feeding my interest in technology, due to the country's weak STEM curriculum. Nevertheless, at a young age, I decided that I would not let these barriers hold me back. One of my high school professors recognized my motivation to learn and he challenged me, outside the classroom, with small STEM projects. By saving my small weekly allowance, I bought materials to build different projects and to continue learning. The main drivers that have always kept me moving forward are curiosity, eagerness to learn, and perseverance to become the best at what I do.

When I graduated from high school, I had my entire career planned. After high school, I attended a local university in Honduras, Universidad Tecnologica Centroamericana (UNITEC). At UNITEC, I started my path towards my Bachelor of Science degree in Mechatronics Engineering. However, my convictions were put to a test when in 2015, one year before completion of my degree, I had to leave my family and friends to move to New York.

I felt lost in New York, because the culture and education system was foreign to me. Furthermore, I was financially handicapped. It was at this time that I felt unsure of my future. Nonetheless, I have been a strong believer that when life's trajectory reaches its lowest point, an inflexion point is approaching. After a few weeks of adaptation, I decided not to give up and I took on several part-time jobs to save money towards my college tuition.

It wasn't until I found Vaughn College of Aeronautics and Technology that I re-discovered the spark that fired back my engines. As one of the few institutions nationwide to offer a Mechatronics Engineering program at the undergraduate level, Vaughn College lives up to expectations – its outstanding Mechatronics curriculum fed my curiosity and my passion for learning. Each professor at Vaughn not only focuses on developing their students' engineering and technical skills but also seeks to support student interests and goals. During my time at Vaughn, I joined the Society of Hispanic Engineers (SHPE), and Engineers Without Borders, and I also participated in the Robotics club and the UAV (Unmanned Aerial Vehicle) club,

engineering groups where I practiced the skills I now apply in my current industry role. Not only did Vaughn support me with a scholarship to continue pursuing my dreams, but this college also sponsored my trip to attend SHPE's National Conference in 2018, where I obtained my first internship as Product Engineer Intern with John Deere. With my determination to be successful and Vaughn College's support, I obtained my Bachelor of Science in Mechatronics Engineering in 2019, thus beginning a rewarding career.

At John Deere, we work towards shaping a sustainable future in which the land and technology work in harmony through precision agriculture. As part of John Deere's Engineering Development Program, I have had the opportunity to experience different engineering roles within the company. I have worked as a Process Control Engineer where I applied my knowledge on programmable logic controllers to implement system interlocks and mistake-proofing solutions across a factory environment. During my role as an Electronic Design Engineer, I completed an intellectual property application for an Air Conditioning Control system I designed based on Kalman Filter, a subject that Dr. Shouling He covered during one of our courses. In my current role as a Factory Automation Engineer, I have leveraged my knowledge on embedded systems to design more efficient and reliable testing solutions for John Deere's Utility Tractors. Regardless of the engineering career path I decide to pursue, I am confident I have the knowledge and resilience to succeed. Vaughn College's Mechatronic program prepared me with the skills I need to excel in today's competitive market.

Life can surely have unexpected turns; nevertheless, if we believe strongly enough in our dreams and have the strong conviction that we will achieve our goals, great things can be accomplished. Be curios and keep learning, challenge yourself and be competitive, but most important of all believe that you have what it takes to reach greatness. At Vaughn College, you will surely obtain the skills to succeed, it is up to you to accept the challenge.

Utsav Shah, Class of 2018
Systems Engineer, Northrop Grumman
Bachelor's Degree in Mechatronics Engineering, 2018

While growing up in India, I was always amazed by the expanse of the universe and how we were able to send people to the moon. Even more surprising is that we still don't know about many aspects of the moon, which makes me curious about how we can continue to explore all of its secrets. I still remember the model of the Columbia space shuttle that I had as a child and how I had to put many pieces together to make it, knowing all the while that the actual space shuttle was infinitely more complex.

After moving to NYC in the middle of my senior year in high school, it was pretty hectic to adapt to a completely new education system and get on track with SAT and college applications. Even in the middle of all this, I somehow learned about this club where they were building model rockets. I quickly joined the club and started to learn more about the different engine types and how they work. I quickly became the president of the club and we started launching model rockets with other members. It was at that time when my professor mentioned to me about Vaughn College of Aeronautics and Technology and how they have some great programs that I would be interested in. I applied for and was accepted into their Mechanical Engineering program, after listening to Dr. Rahemi at a Vaughn College open house.

Soon after I started my sophomore year, I heard about this new club that was being established called the UAV club, where they were putting together a team to build racing drones. It just felt like the perfect place for applying what theory I was learning in classes and seeing how it is used in real life. I became so enthused with the activities in this club that I was always there before and after my classes, working on drones. Eventually, I became the president of the club and participated in winning competitions against some of the big-name colleges. Because Vaughn college is such a small school, I always had that connection with the professors and mentors, so that if I needed anything technical, or even funding for the club, they were quickly able to contact other people in the industry who would help us out.

After working as a robotics and automation engineer in the industry for almost three years now, I can confidently say that what I learned from the UAV Club, as far as application of my theoretical knowledge, has been the most valuable aspect of my Vaughn College education. Lastly, all future students should realize that even if they don't have the best grades in all their classes, creating some time to join technical clubs prepares them for real-life challenges that they will face in the industry.

The Impact of Vaughn's Grant-Supported STEM Activities

By Hossein Rahemi, PD of HSI-STEM Title III Grant

Published in the Voice of Hispanic Higher Education, Volume 29, Number 2, Summer 2020

Founded in 1932, Vaughn College of Aeronautics and Technology is a Hispanic-Serving Institution that continues to develop a much-needed pathway to increase accessibility for Hispanic students to enroll in the College's engineering degree programs and engage students in STEM activities.

In 2016, Vaughn received $5.9M in funding from the U.S. Department of Education HSI-STEM Title III-Part F grant. A portion of the grant provided funding to support expansion of student involvement in STEM-related scholarly, practical hands-on, and community outreach activities including student engagement in paper and poster session competitions at technical conferences—American Society for Engineering Education (ASEE), Latin American and Caribbean Consortium of Engineering Institutions (LACEEI), Institute of Electrical and Electronics Engineers (IEEE), American Institute of Aeronautics and Astronautics (AIAA), Society of Women Engineers (SWE) and Society of Hispanic Professional Engineers (SHEP)—and involvement in robotics, unmanned aerial vehicle (UAV), formula SAE, and Rover club activities and competitions. These hands-on and scholarly activities improved student performance and retention and graduation rates in Vaughn STEM programs. These experiences empower our students with a competitive edge and provide them with valuable experiences for the workplace. Below are the results of some current initiatives the College has implemented to attain the goals and objectives of this STEM plan.

1) **Scholarly Activities:** As a result of grant-supported activities, Vaughn's engineering students participated and presented their research papers in the 2019 LACCEI International Conference in Montego Bay, Jamaica, and they received all three top awards (First, Second, and Third place) in the student paper session competition. Also, Vaughn's engineering students participated and presented in the 2019 International Mechatronics Conference and in the 35th Southern Biomedical Engineering Conference. Vaughn's Students received the Best Presenters Awards of both of these conferences.

2) **Technical Competitions:** With the support of HSI-STEM grant funding, Vaughn's UAV club participated as a finalist in the 2019 Vertical Flight Society (VFS) Micro Air Vehicle competition and finished second in both the autonomous and the remote control categories in this challenging competition. Vaughn's robotics team advanced to the playoff round of the 2019 World Robotics Championship and retained its standing as one of the top competitors of this challenging competition, by winning the 2019 World **Create Award**. Also, Vaughn's SHPE student chapter participated in the 2019 SHPE Conference and the team competed in the Extreme Engineering Challenge, winning third place.

3) **STEM Workshops and Outreach Activities:** For the academic year 2019-2020, students in Vaughn's technical clubs (robotics, UAV, and SAE) and Vaughn's student chapter of professional societies (SWE, EWB, NSBE and SHPE) organized and hosted several STEM-related workshops for middle, high school, and community college students during Vaughn's Annual Manufacturing Day, Vaughn's International Drone Day, and Vaughn's Annual STEM Day. They also provided assistance to many high schools in hosting their regional robotics and drone competitions. Vaughn's UAV team continues to assist the Cradle of Aviation Museum in developing and hosting drone

games and competitions for high school students. Project director, Dr. Hossein Rahemi, along with faculty, attended some of these events to interact with participants and to increase awareness of Vaughn's engineering programs**.**

Given the rapid pace of technological advancement, the HSI-STEM grant activities assist Vaughn engineering students in developing an appreciation for lifelong learning which sustains them in meeting their future professional challenges. The ultimate goal is to engage and prepare students for their future in engineering research and innovation and to enhance their critical thinking, problem solving, communication, teamwork and leadership skills. The Vaughn community motivates, engages and provides our students with the knowledge and skills necessary for success in their career path, and together we can all become responsible individuals within the society we serve.

Curriculum and Career Advisement Day: Career Conversations with Engineering Students

Thursday, September 17, 2020
11 am – 12 pm
Virtual Zoom Meeting

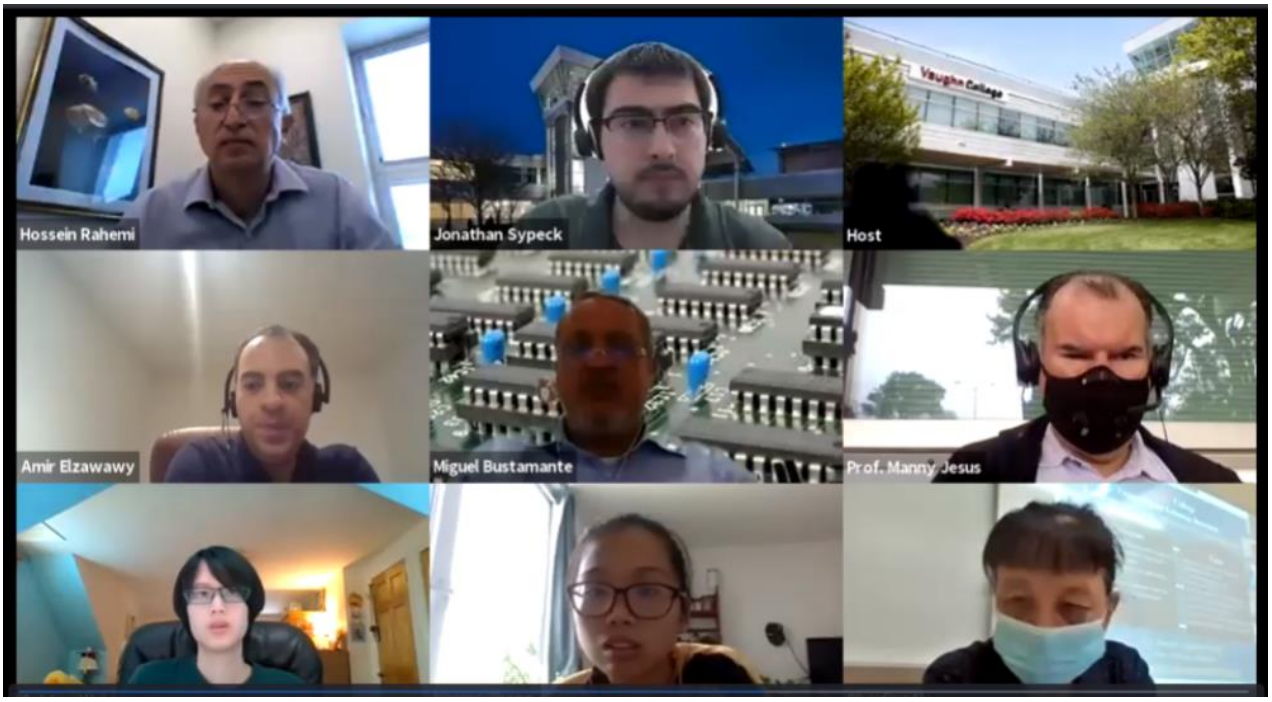
The engineering and technology department hosted its 2nd Annual Curriculum and Career Advisement day with students in engineering and engineering technology programs. Dr. Rahemi, along with coordinators in Students Activities and Engagement, organized this virtual event to provide curriculum and career advisement to all engineering and engineering technology students. This virtual event covered topics related to curriculum as well as to activities in which students should participate in order to enhance their career opportunities while studying at Vaughn.

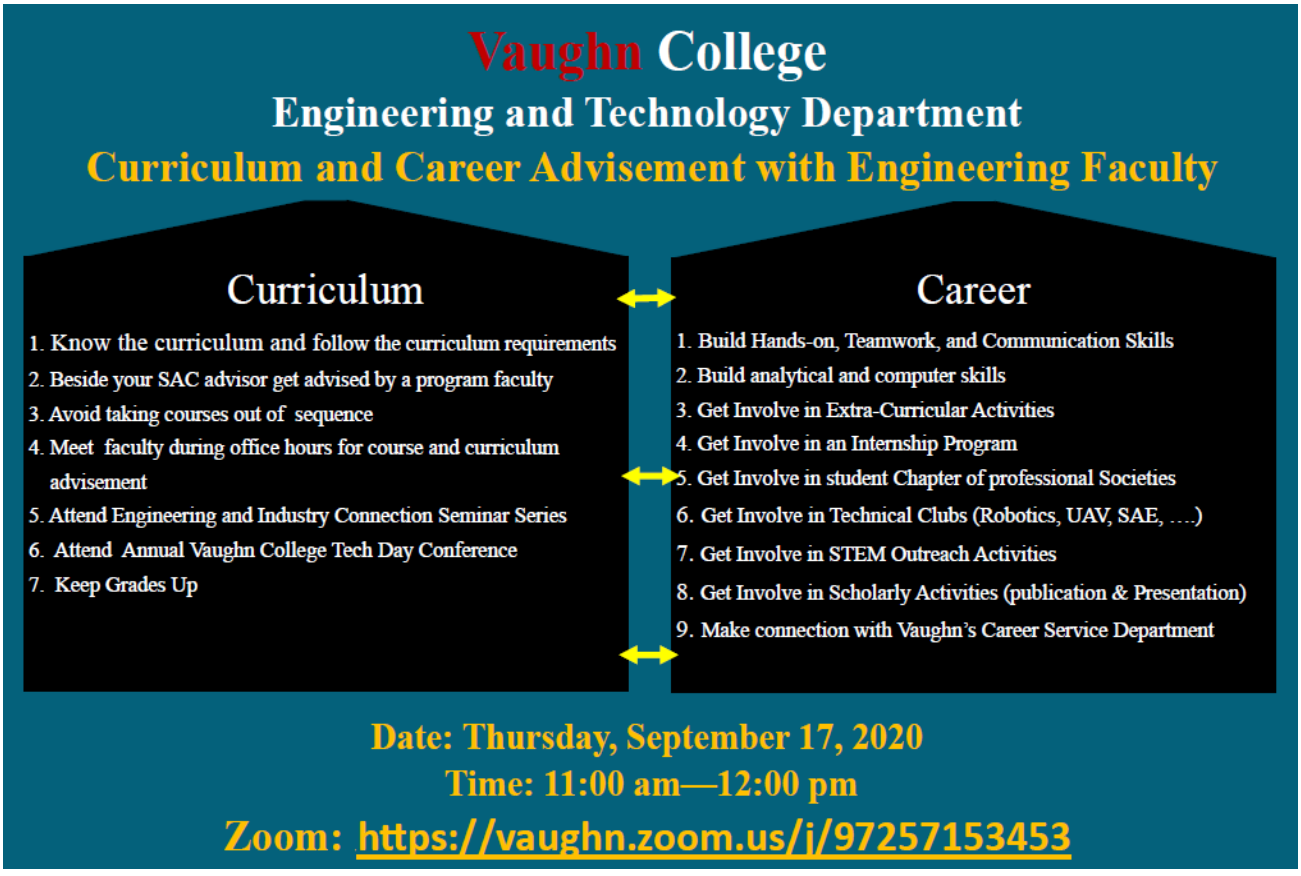
Department chair, program coordinators, and faculty discussed, in detail, the following curriculum and career strategies with students.

1. Know your curriculum – Review the curriculum sheet, learn about the curriculum offerings and contents (Math and Science, technical, and general education), technical electives, and prerequisite and corequisite requirements.
2. Curriculum Advisement – Meet you curriculum advisor at Student Advisement Center (SAC) and get curriculum and registration advisement.
3. Avoid taking courses out of sequence – Many core courses require prerequisites, taking course out of curriculum sequence may result in missing prerequisites and consequently may delay graduation.
4. Get advised by a program faculty – Meet program faculty during their office hours and get course and curriculum advisement.
5. Attend Engineering and Industry Connection Seminar Series – These seminars will help all students to learn about current technological advancement and engineering innovation, as well as provide an opportunity for students to interact with industry leaders. The main objective of this seminar series is to provide our students with a greater appreciation for engineering education.
6. Attend Annual Vaughn College Technology Day Conference – This annual conference helps all students interact with Vaughn's industry advisory members as well as learn about graduating students capstone projects presented in the afternoon session of this annual gathering. Attending and presenting in this annual conference helps students to enhance their career opportunities.
7. Keep Grades Up – Having a GPA of 3 or better increases a student's chances of both obtaining an interview for an internship and employment with many engineering industries.
8. Build hands-on teamwork and communication skills – These career building skills can be attained through hands-on laboratory projects, capstone courses, and involvement in

technical clubs (Robotics, UAV, SAE, et) and student chapters of professional societies (SWE, SHPE, EWB, NSBE, LACCEI).

9. Build Analytical and Computer Skills –Analytical and computer coding knowledge and capabilities are two important skills for pursuing a successful career in STEM Fields.
10. Participate in Extra-Curricular Activities – To further enhance career opportunities and cultivate creative ideas, one should consider involvement in extra-curricular activities such as technical clubs, competitions, and STEM workshops.
11. Participate in an Internship Program – Internship programs not only introduce one to the industry environment but also expose one to real-world engineering projects and career-building skills. The department supports and encourages all students to attend career fair conferences. In the past couple of years, those students who attended in SWE, SHPE, and NSBE Career Fair conferences, received both internship and full-time position offerings.
12. Participate in Student Chapters of Professional Societies - Involvement in student chapters of professional societies introduces one to innovations in the STEM fields and provides professional networking opportunities with engineering industries.
13. Participate in Technical Club Activities – Involvement in technical clubs such as Robotics, UAV, SAE, increase creativity and provide an opportunity to apply classroom knowledge to the actual building of an engineering system. The creative mindset acquired through these experiences provides a lifelong edge in one's professional career.
14. Participate in STEM outreach activities - Organizing and hosting STEM workshops during Vaughn's Annual Manufacturing Day, Annual International Drone day, SWE Annual Conference, and Vaughn's Regional High School and College Robotics competitions further enhances leadership and career opportunities in STEM fields.
15. Participate in Scholarly Activities - Publications and presentations at technical conferences such as ASEE, SEM, LACCEI, ASME, SWE, AHS, COMSOL, IEEE, and VCJET integrate career-building skills and contribute to success in professional careers and in continued education.
16. Connect with Vaughn's Career Service Department – We encourage everyone to be in touch with Vaughn's Career Service and to participate in their workshops and events related to resume writing, internships, career fairs, and graduate school fairs.





2020 Virtual Curriculum and Career Advisement Day, Thursday, September 17

VAUGHN COLLEGE 2020 COMMON READING SPEAKER SERIES

The 2020 Common Reading Program's selection is Eddie Glaude's 2020 book, *Begin Again*: *James Baldwin's America and Its Urgent Lessons for Our Own.* Professor Glaude is the James S. McDonnell Distinguished University Professor of African American Studies at Princeton University where he is also the Chair of the Center for African American Studies. He is the author of several books on black culture and a frequent guest on several cable and tv news programs.

Given the overwhelming national response to incidents of racial injustice in American society and the intensity of the current national discussion challenging the race-related status quo, Eddie Glaude's new book *Begin Again* promotes discussion on our campus about much-needed new rules of engagement in our society. Our students are thus be reading and talking about a book very much in the public eye and prominent in the current national discussion.

The central consideration running throughout *Begin Again* is how James Baldwin, who was writing in the 60's, speaks to our current era. The title of this book is taken from a line in Baldwin's novel *Just Above My Head* and refers to the necessity for a third founding of America. The first founding was the Civil War and Reconstruction; the second was the multiracial freedom struggle of the 60's. As the title of his new book suggests, Glaude believes we must "begin again" to pursue a *third* founding, through which Baldwin's quest for a New Jerusalem, or true multiracial democracy, will be achieved.

Professor Glaude had an exclusive engagement with our students, in which he spoke about the ideas in his new book, at the Common Reading Zoom presentation on Sept 22, 2020. Throughout his presentation, the continual comments from students in the sidebar panel reflected their engagement and critical thinking. After his presentation, students asked Professor Glaude their individual questions. Discussion groups are also being planned in connection with this Common Reading selection. It is through events such as these that Vaughn College fulfills its vision to *change the world one student at a time, with a transformational education.*

Vaughn's Annual Assessment Day, December 11, 2020
Title: Assessment to achieve ABET Accreditation for Engineering
Presenter: Hossein Rahemi, Engineering and Technology Department Chair

The Engineering and Technology Department chair presented the department assessment process and the results of the recent EAC ABET virtual visit that took place from November 15 through 17, for the purpose of initial ABET accreditation of mechanical and electrical engineering programs to the Vaughn community on Friday, December 11 during the morning session of Vaughn's Annual Assessment Day. Dr. Rahemi's presentation covered the department's roadmap for a successful assessment and continuous improvement that involved with 1) developing and distributing assessment documentations, 2) collecting and analyzing assessment data, 3) identifying shortcomings in student outcomes, and 4) introducing and implementing action plans for improvement. He emphasized that this is the process we follow through our self-study reports, in order to be in compliance with the ABET standards and criteria requirements.

Dr. Rahemi continued to talk about the development process of ME and EE Self-Study reports addressing EAC ABET's template questions based on eight program's criterions related to students, program educational objectives, student outcomes, continuous improvement, curriculum, faculty, facilities, and institutional support as well as program criteria and Accreditation Policy and Procedure Manual (APPM). His presentation addressed the following items that promoted the success of ABET's review of our mechanical and electrical engineering programs.

- **Student Outcomes Assessment:** Our assessment process is conducted based on "1 through 7" ABET students outcomes and those are 1) Complex problem solving, 2) design, 3) communication, 4) Professional and ethical responsibilities, 5) teamwork and leadership, 6) Conduct experimentation and analyze data, 7) Acquire and apply new knowledge as needed. As a direct measure, courses within the program are used to assess these student outcomes. Also, surveys such as employer, internship, and Tech Day evaluation of capstone project are used to measure attainment of these student outcomes

- **Outcomes' performance Indicators (PIs):** The program faculty determined appropriate performance indicators and subsequent assessment tools for each outcome. As shown in this outcomes performance indicator table, each outcome is subdivided into performance indicators (PI) to provide additional information about our outcome assessment and subsequently target improvement, should it be warranted. Course tasks and assignments are used as a direct measure to assess performance indicators of each specific outcome

Table1: Performance Indicators for each Student Outcome

Student Outcome	Performance Indicator	
1. Ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science, and mathematics	PI-1A	Able to take a complex engineering problem and set up an approach to solve it
	PI-1B	Able to apply principles of engineering, science, math and solving complex engineering problems.
2. Ability to apply engineering	PI-2A	Understanding requirements

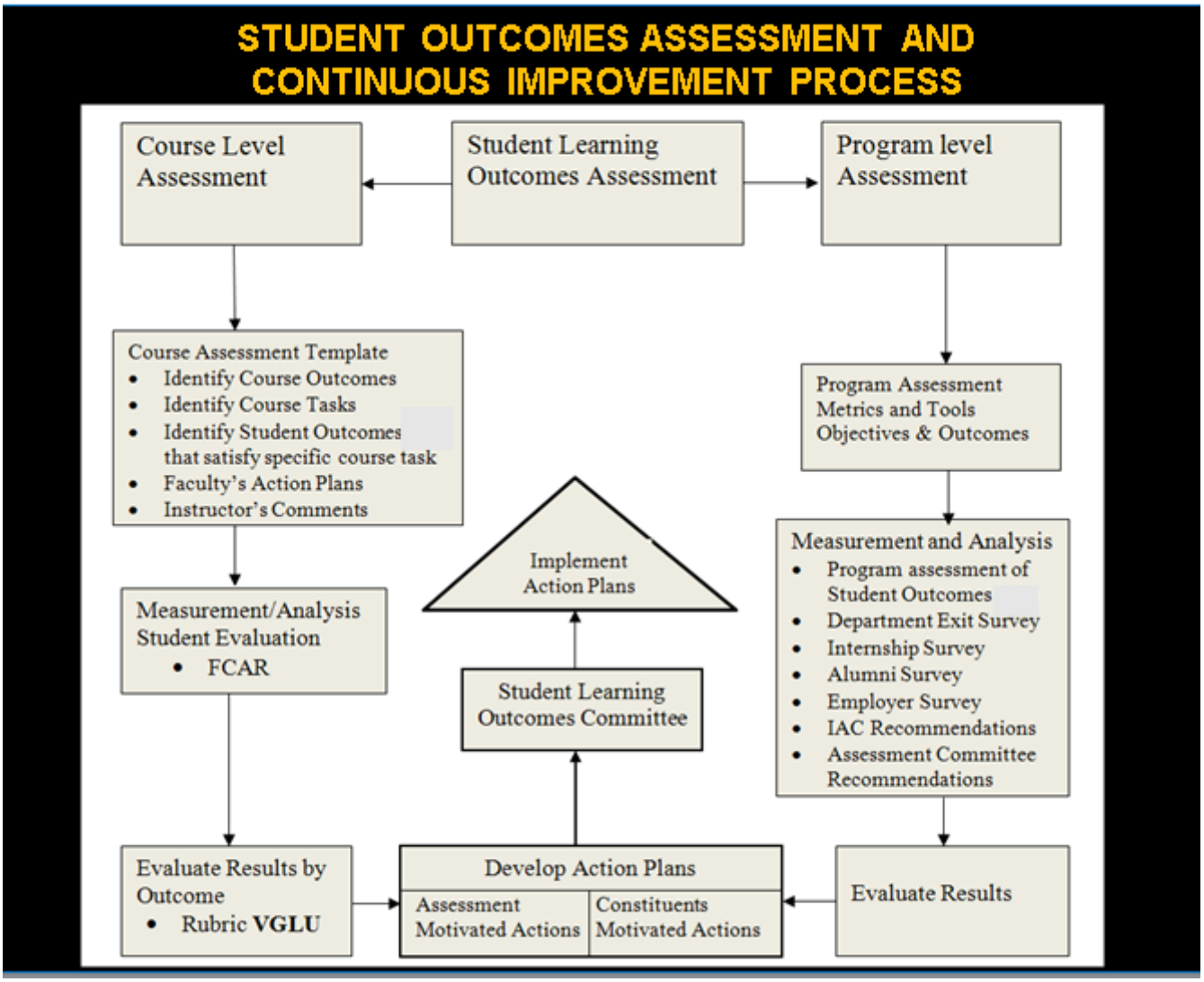
design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	PI-2B	Developing design space or conduct trade studies
	PI-2C	Applying design constraints, standards and other factors
	PI-2D	Obtaining an effective solution that satisfies the requirements
3. Ability to communicate effectively with a range of audiences	PI-3A	Possess good writing skills and organization
	PI-3B	Possess good oral presentation skills and effective data presentation format
	PI-3C	Informative and succinct content targeted to the intended audience
4. Ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	PI-4A	Identifying relevant global, economic, environmental, societal issues when proposing an engineering solution
	PI-4B	Understands consequences of poor work quality or omissions
	PI-4C	Understands the potential consequences of unethical behavior
	PI-4D	Understands what to do if others exhibit unethical behavior
5. Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	PI-5A	Demonstrates ability to set goals and plan tasks
	PI-5B	Completes assigned tasks on time and with quality
	PI-5C	Open to other disciplines' issues and input and constructively participates in team meetings/discussions
	PI-5D	Supports team decision process and supports final decisions to meet objectives
6. Ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	PI-6A	Demonstrate knowledge of experimental approaches
	PI-6B	Demonstrate knowledge of data collection methods
	PI-6C	Has experience conducting experiments
	PI-6D	Demonstrate ability to analyze and interpret data using modern engineering tools and equipment
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	PI-7A	Demonstrate ability to acquire new knowledge and skills that are important to an engineer
	PI-7B	Can list ways to continue learning and maintaining currency in the field

- **Continuous improvement:** Our Continuous improvement process is based on both course and program level assessment. In course level, 3 to 4 higher level core courses are used to assess each student outcome based on assigned course tasks. In program level, questions from constituents' surveys are used to address attainment of each student outcome. The department collected course and program data, evaluated results and

developed assessment-motivated and constituent-motivated actions to address and improve any shortcoming through the program.

- **FCAR** known as faculty course assessment report is used to assess each student outcome through course tasks based on performance indicators. As an example, MEE370, finite element course is used to assess outcome 1, complex problem solving, and outcome 7 life-long learning. For this course, faculty designed course tasks to assess performance indicators of outcome 1 and outcome 7 as it is shown in FCAR template.

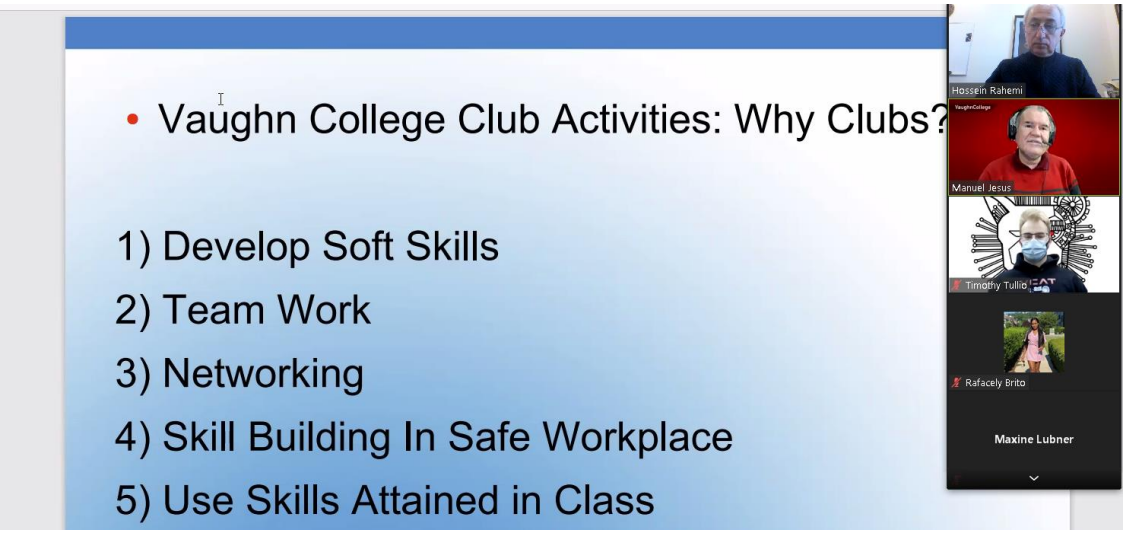
- **Student Outcomes Evaluation by Constituents Surveys:** In constituents' table, department used results of questions from constituents' surveys (exit, alumni, internship, employer, and tech day) to measure attainment of each student outcome, and in continuous improvement column we discuss the results and develop necessary action plans, if the result is below our threshold for success.



Virtual STEM Day Presentation by Engineering Clubs

Thursday, March 4, 2021
11 am – 12 pm

On Thursday, March 4, 2021, the engineering department hosted its 2nd annual Virtual STEM Day. The department chair opened the session and thanked all the participants and especially the clubs' leaders for their contribution to this virtual event. Professor Jesus, 3D/CNC curriculum designer and STEM Liaison, served as the moderator of this event. Professor Jesus started the session with his talk, "Why Join Clubs?", and his presentation introduced audiences to professional skills, such as, communication, teamwork, safety, networking, and hands-on as well as other career building skills that one may benefit from, by joining a technical club or student chapter of a professional society.



After his introductory talk, Prof. Jesus introduced leaders of Vaughn's technical clubs and student chapters of professional societies (Robotics, NSBE, Rover, SHPE, SWE, and UAV) to address the Vaughn community with a presentation about their annual professional activities. During this virtual event, each club provided a detailed discussion of their activities as listed below

1. STEM Workshop
2. STEM Outreach
3. Involvement in Student Chapters of Professional Societies
4. Conference Participation, Presentations, and Publications
5. Technical Competitions
6. Accomplishments
7. Career Fairs

Virtual STEM Day Presentation by Engineering Clubs, March 4, 2021

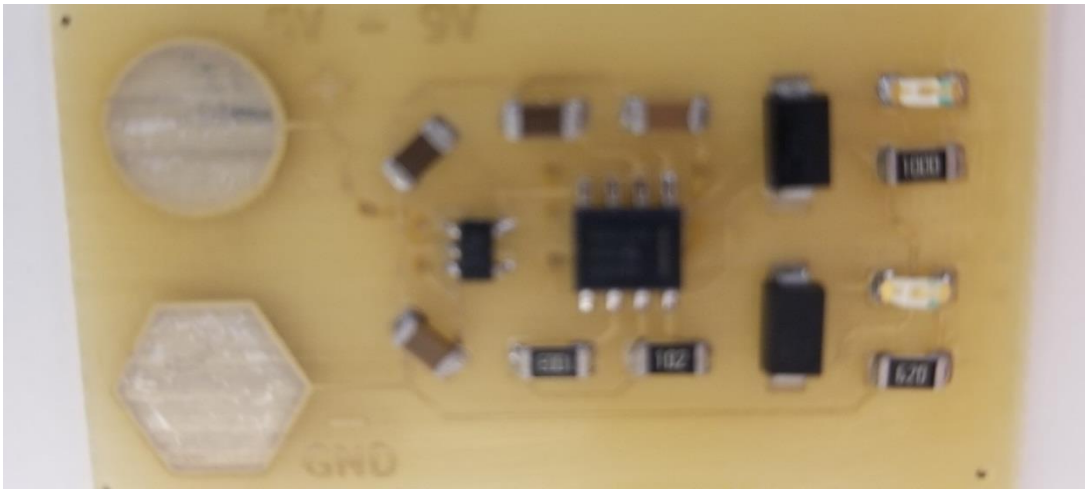
In conclusion, Dr. Rahemi, thanked all leaders of Vaughn's technical clubs and student chapters of professional societies for their excellent presentation and encouraged all participating students to join Vaughn's technical clubs and be involved in extra-curricular club activities. He emphasized how involvement in technical clubs and student chapters of professional societies further enhances hands-on, leadership, teamwork, and other career-building skills as well as leading to the cultivation of creative ideas. Involvement in these clubs introduces one to innovations in the STEM fields and provides professional networking opportunities with engineering industries. Finally, he expressed his sincere gratitude to the Department of Education federal grant (Title III, Part F, HSI-STEM and Articulation grant) which provided necessary funding support to engage Vaughn's students in STEM and professional development activities.

HSI-STEM
SCIENCE • TECHNOLOGY
ENGINEERING • MATH

BotFactory SV2 Professional Printable Circuit Board (PCB) Printer

In fall 2020, based on recommendation of the EE advisory members and with support of the HSI-STEM grant, the engineering department purchased a Printable Circuit Board (PCB) from BotFactory for a price of $20,146 to provide EE and EET students with a hands-on approach to circuit board design and manufacturing.

The BotFactory SV2 Professional is Botfactory's second-generation printer capable of producing up to four-layer PCBs and automatically placing Surface-Mount Technology (SMT) components. Circuit boards produced by this 3D printer are able to qualify for the IPC Class 2 standard, meant to be used in consumer products such as televisions or computers. This high capability, which is easy to use, results in quick fabrication of PCBs for any students/staff who know how to design such circuit boards. Below is a sample board created with our printer, which accepts an input of 5V and uses a timer to blink LEDs. This board was produced in approximately 30 minutes and is one of the simplest PCBs that can be produced with the hardware; even microcontrollers such as an ATMEGA2560 (heavy-duty 8-bit Arduino microcontroller) can be automatically soldered to any board.



The interface is straightforward, easily accepting any produced PCB design file from the most popular design applications, such as Altium, KiCAD, or Solidworks' Electrical PCB Design suite. After providing the printer the documents and specifying what components are held in which bay, the printer can print the traces and insulators, apply soldering paste, and place components with the user only needing to swap the heads when requested. Using computer image recognition, the system can automatically identify and align components to where they are supposed to be. An integrated heated bed cures the board and self-solders connections.

Botfactory is willing to be an intermediary for any future investigation on the purchase of a PCB design software. In addition, they are in heavy demand for interns/employees, and as a company with connections to several high-class manufacturing positions such as Sikorsky, Lockheed-Martin, and official contracts with the US Military, there is significant room for growth in our student body. Having this printer, allow Vaughn's students in Mechatronics, EE, and EET courses to learn PCB design and manufacturing process that can further enhance their knowledge and hands-on skills and prepare them for their career path in this demanding STEM field.

BotFactory Printable Circuit Board (PCB) Printer Training

The Department chair, with coordination of the engineering department's Lab Tech, Alaric Hyland, organized a two-day PCB Training sessions that took place at Vaughn's Control Systems and Robotics lab on Friday, Feb 26th and Thursday, March 5th from 12 pm - 2 pm with BotFactory. The PCB printer and training is supported by Title III HSI-STEM grant funding.

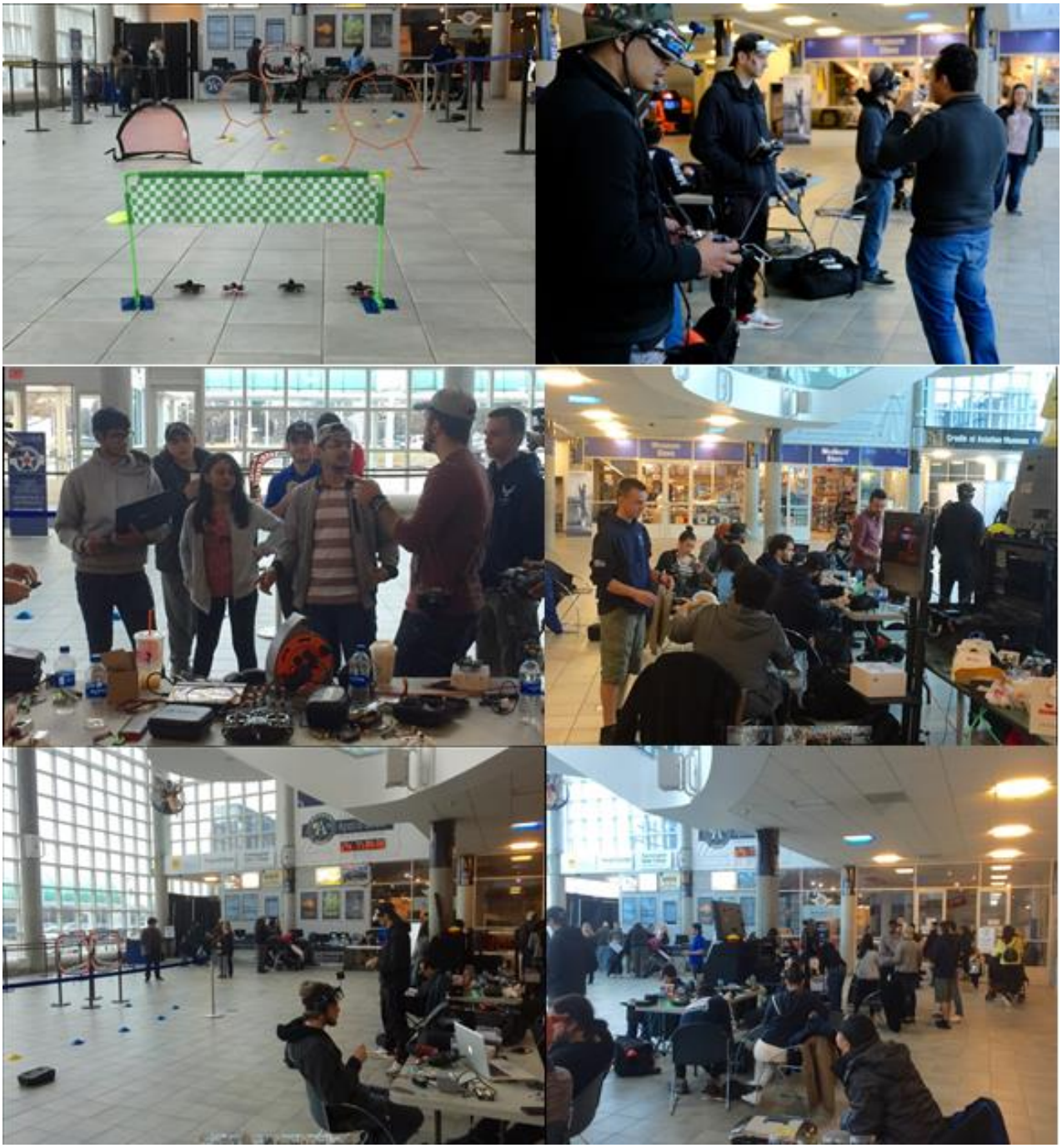
For these training sessions, two representatives, J.F. Brandon (sale person) and Nicholas Vansnick (CEO), from BotFactory provided hands-on PCB design and manufacturing training to two Vaughn's faculty members, Drs. Shouling He and Miguel Bustamante, and two lab techs, Alaric Hyland and Deno Jordan. Topics covered during these trainings were related to operation and functionality of the PCB printer, loading and manufacturing process of PCB, as well as software recommendations for designing PCBs.

The knowledge gained from this training is very helpful in providing our engineering and engineering technology students with the current PCB hands-on skills that can further enhance their career opportunities in this demanding field.

Faculty and Lab Tech PCB Training by BotFactory .

Community Outreach Fun Fly and Tiny Whoop Race, Saturday February 1, 2020

The Vaughn College UAV Club hosted its first "Community Outreach Fun Fly and Tiny Whoop Race" event at the Cradle of Aviation Museum on February 1st. The event was free and open to the community. Many drone hobbyists and FPV pilots, as well as the locals from the area, attended the event. All visitors had the opportunity to fly at the event. Some flew their own drone during the free fly period, or during the race of flying drones that the UAV club brought for the visitors. The UAV club also held a raffle for a hands-free drones, and many excited attendees took part. There were also prizes given to the winners of the races. The hobbyists, the FPV pilots and the Vaughn College students truly enjoyed having the opportunity to fly in the race at the Cradle of Aviation, while the younger children who attended the event had fun flying during the free fly period. The younger attendees also really enjoyed watching the Tiny Whoops go through the hoops and around the obstacles as the pilots raced each other. After the race, the attendees were able to free fly again, and many younger attendees enjoyed speaking to the pilots who took part in the race. The event was concluded by announcing the raffle winner and the winners of the race. This event provided the pilots with the opportunity to demonstrate their skills, and it allowed the community to learn more about drones by speaking to drone hobbyists, as well as to the Vaughn UAV club.



Community Outreach: Tiny Whoop Race at the Cradle of Aviation, February 1, 2020.

Engineering Seminar Series

Tuesday, March 3, 2020
11 a.m. to 12 a.m., Rooms E101 & E103

Presenters: Ariel A. Ferrera, senior Mechanical Engineering student and Jacqueline Oricchio senior Mechatronic Engineering student
Topics: 1) Designing and analyzing Medical Device such as Reamers and Oscillating Saw Blades, 2) Rolls-Royce Engine Models through 3dsMax

In this seminar, Ariel and Jacqueline, who participated in a ten-week summer internship programs with Stryker and Rolls-Royce, addressed the Vaughn community about this summer internship project and life-long learning experiences they both gained through their projects.

Ariel Ferrera, a senior mechanical engineering student, talked about his assigned tasks with the Stryker (Medical Device Company) in the Research and Development department, where he worked on designing and analyzing medical device tools such has reamers and oscillating saw blades to reduce thermal necrosis in orthopedic knee surgery. For this project, he used finite element analysis and was able to preliminary test design concepts for critical bone cutting tools. He explained how the knowledge he gained through courses such as computational engineering and finite element analysis helped him to successfully complete this internship program.

Jacqueline Oricchio, a senior mechatronic engineering student, talked about her assigned tasks with Rolls-Royce, in the civil and defense aerospace division. Her first internship with Rolls-Royce was in the summer of 2018 when she worked as a Customer and Product Training Intern and her assigned tasks consisted of taking 3d pdfs of engines and making the proper adjustments to them. These tasks included putting components in their proper locations, adding textures to the models, or separating the engines into separate modules. Her second internship in the summer of 2019, consisted of working with the Industrial Engineer team on updating their Optimizers, as well as working directly under the Chief Manufacturing Engineer to make a procedure/policy for lifting, transporting, and presenting parts in two departments.

Both Ariel and Jacqueline explained how the knowledge they gained through technical courses within their degree programs helped them to successfully complete their internship programs.

Their presentation followed with 15 minutes of open discussion.

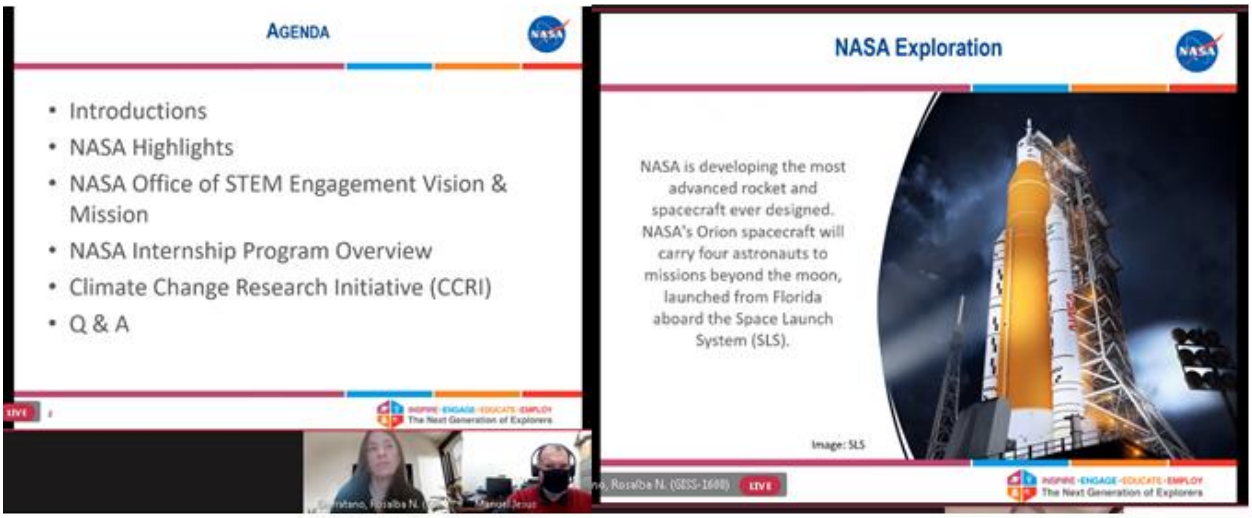
An overview of summer internship programs with Stryker and Rolls-Royce

Industry Connection Seminar

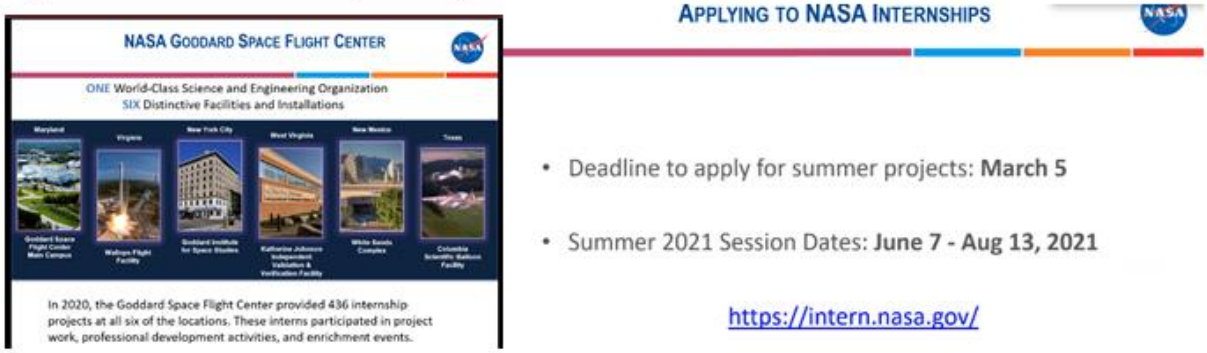
Thursday, Feb 11, 2021
11 a.m. to 12 p.m., A Microsoft Teams virtual Seminar

Presenters: Mr. Matthew Pearce, NASA Education Programs Specialist
Ms. Rosalba Giarratano, Pathways Intern for Space Studies
Topic: An introduction to NASA, NASA Goddard Space Flight Center, NASA Goddard Institute for Space Studies and NASA Internship Opportunities

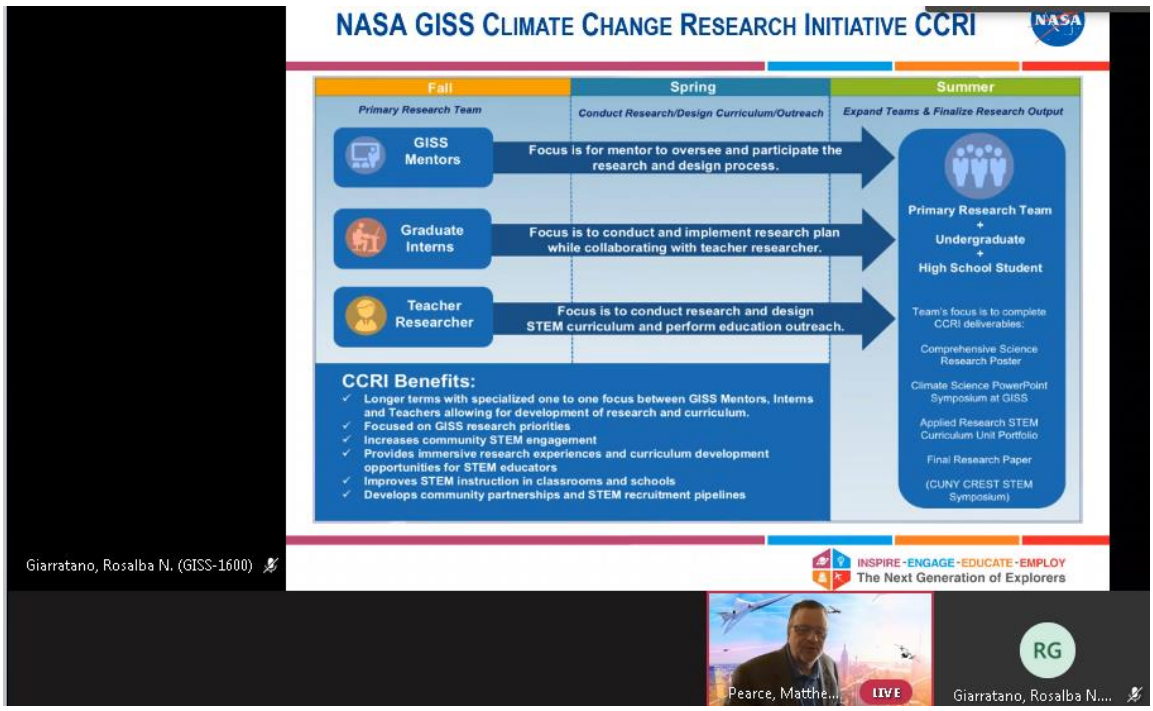
Mr. Matthew Pearce, National Aeronautics and Space Administration (NASA) education programs specialist and Ms. Rosalba Giarratano, Pathways Intern at the Goddard Institute for Space Studies, addressed the Vaughn community on Thursday Feb 11 as part of the College's Industry Connection Seminar series. For this Microsoft Teams Virtual event, both Ms. Rosalba Giarratano and Mr. Pearce's presentation covered an overview of NASA, NASA Goddard Institute for Space Studies, NASA STEM Workforce Challenges and they talked about all available STEM Internship, Fellowship, and other career opportunities with NASA.



Ms. Rosalba Giarratano's presentation provided an insight into current internship options for students, STEM engagement, and NASA's internship application and interview process. Her own experiences as an intern resonated with students. She provided tips to students about what is best to include in their applications, opportunities presented to interns once hired, and the importance of the work they accomplish.



Mr. Pearce spoke about the space station opportunities for researchers, students, and educators, NASA GISS climate change research initiative (CCRI), the NASA Moon to Mars mission, and research benefits for humanity. He talked about the current state of the workforce and summer 2021 CCRI NASA internship opportunities how to apply.



Summer 2021 Opportunities

Following are internship opportunities that have been announced for Summer 2021 The application deadline for these opportunities is **March 5, 2021**.

To obtain an up-to-date list and to read a description of each opportunity, visit the NASA Internship Opportunities projects listing and select GISS in the search form's "center" field.

- Advancing Cloud-Masking Capabilities for Satellite Imagery over Snow
- Arctic-El Niño Teleconnection and Its Impacts on Extreme Weather Events
- CCRI - Atmospheric Rivers in a Changing Climate
- CCRI - Characterizing the Urban Land Surface Temperature
- CCRI - Climate Change in the Hudson Estuary: Past, Present & Future
- CCRI - Earth Observation Applications for Resiliency
- Code Development for Retrieval of Snow Properties from Satellite Observations
- Dust in the Wind: Soil Dust Aerosols and Daily Variations in Air Quality
- Exploring the Dynamics of Exoplanetary Atmospheres and Oceans with ROCKE-3D
- Research Scanning Polarimeter Monitoring and Data Management

The summer 2021 CCRI projects are seeking both a high school and undergraduate college student intern. The other opportunities are seeking an undergraduate or graduate college intern.

Note: Due to the current public health crisis, the above opportunities will be "virtual". The student will conduct his or her research remotely.

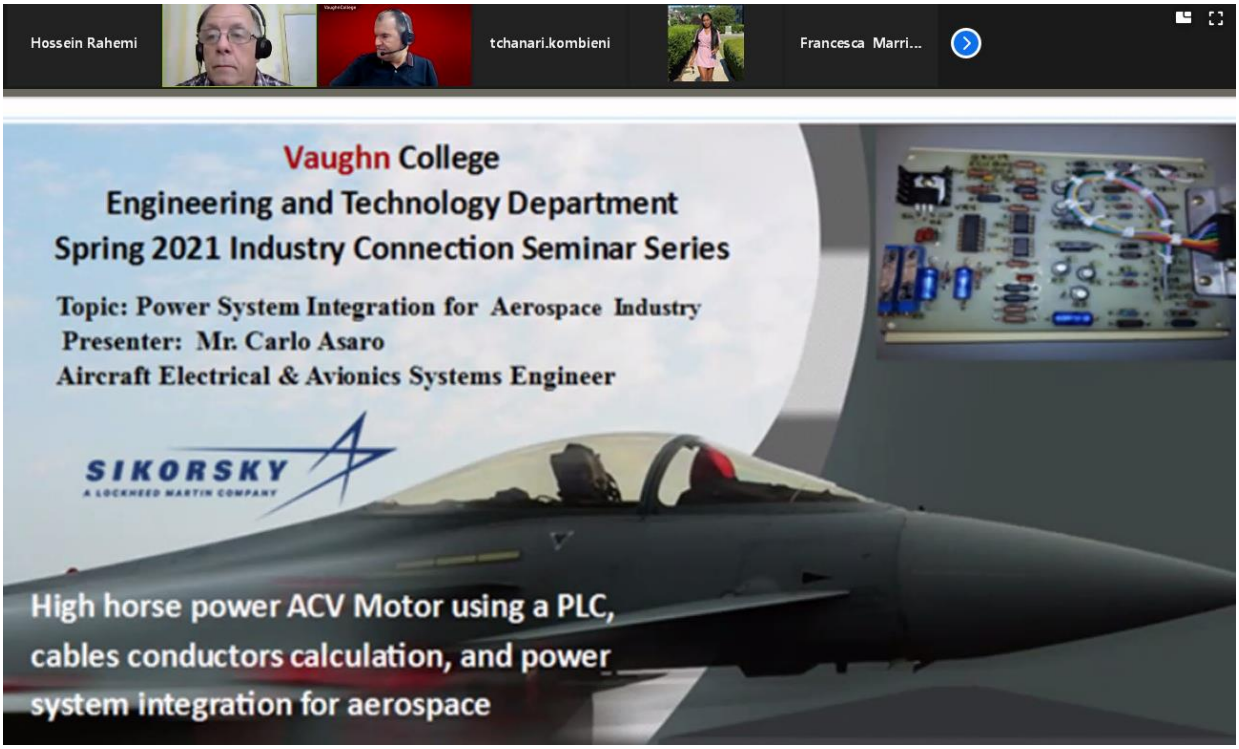
They both encouraged Vaughn's engineering and engineering technology students to apply for opportunities within NASA's valuable career-building options. Their presentations were followed by 20 minutes of open discussion with students.

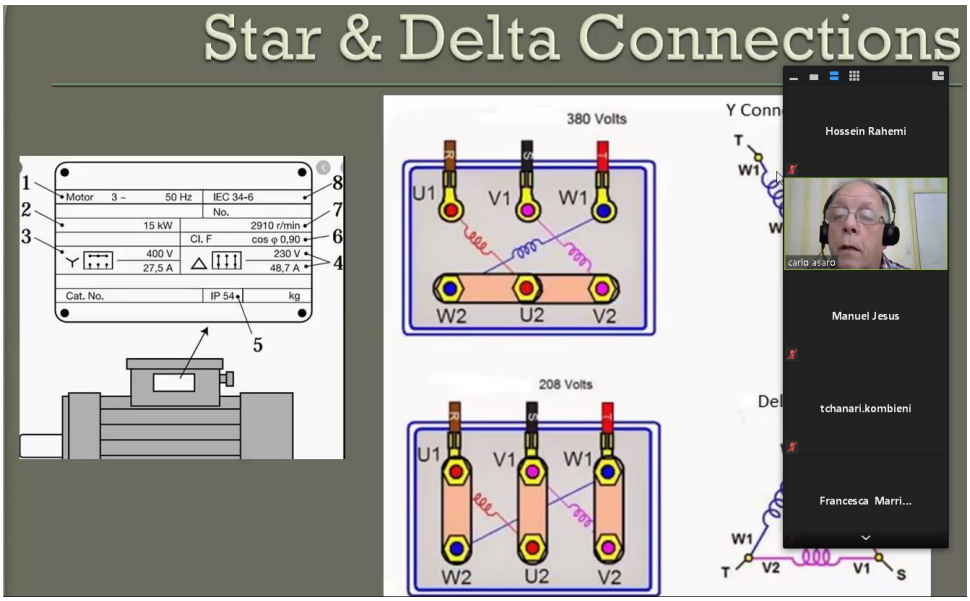
Industry Connection Seminar

Friday, February 19, 2021
11 a.m. to 12 p.m., A Zoom Virtual Seminar

Presenter: Mr. Carlo Asaro, Aircraft Avionics Systems Engineer with Sikorsky, a Lockheed Martin Company
Topic: Power System Integration for Aerospace Industry –
High horse power ACV Motor using a PLC

Mr. Carlo Asaro, an Aircraft Avionics Systems Engineer, addressed the Vaughn community on February 19 as part of the College's Industry Connection Seminar series. Mr. Asaro, has more than 30 years of experience in the industry in research and development, testing and evaluation of rotor-wing electronics with primary focus on power electronics and weapon systems. In this virtual event seminar, Mr. Asaro talked about topics related to high horse power motor, PLC, high power cables conductors, electronics, conduit design and manufacturing process for aerospace industry.





His presentation covered a few of the most important qualifications required for power system design and integration in the aerospace industry. He explored standards for an aircraft avionics power system as well as requirements and testing vital for the installation of high horse power motor using PLC in an aircraft or space vehicle. Moreover, he lectured about his personal experience as an Electrical engineer in the industrial world. His presentation touched real-world topics on high horse power ACV motor using PLC, cables connectors calculation, and power system integration for aerospace. He emphasized AC/DC power courses need to be improved to implement and provide students with the power system hands-on skills and knowledge that is current in the aerospace industry.

At the conclusion of the presentation, the discussion was opened up for questions from students and faculty.

Celebrating Black History and Women's History months with Engineer and Astronaut Stephanie Wilson, March 9, 2021
Article by Dr. Hossein Rahemi and Prof. Manuel Jesus

On Tuesday, March 9th from 10 to 11 am, Vaughn's students, faculty, and Staff in observance of Black History and Women's History months participated in a virtual fireside chat with engineer and NASA astronaut Stephanie Wilson to celebrate accomplishments of this distinguished African Americans Engineer and Astronaut.

Ms. Stephanie Wilson has a Bachelor of Science degree in engineering science from Harvard University and a Master of Science degree in aerospace engineering from University of Texas at Austin. Stephanie worked at both Martin Marietta and the Jet Propulsion Laboratory and in 1996 she was selected by NASA as an astronaut candidate. She is the second African-American women after Dr. Mao Jemison to travel into space and completed three space shuttle missions.

This special virtual meeting was held by NASA to promote STEM in education. Stephanie Wilson shared graciously her career path as an African American Woman involved a STEM career. Specifically, she shared insight regarding her role as an astronaut with NASA during the Shuttle Program and construction of the International Space Station. First and foremost, Stephanie made a point to share that she was an aerospace engineer who worked hard to lay the foundations that eventually brought her to a successful career as a leading astronaut.

For students interested in becoming a NASA team member, she recommended aerospace and other related engineering field as a major. Many of the astronauts started as aerospace engineers who studied STEM extensively. The most important thing is be prepared to make career choices that afford you the best opportunities to set yourself up for a successful career in STEM and NASA. She emphasized the importance of following your passion and your heart's desire. Soft skills were also covered and an extroverted tendency to get to know people better can only help your career path. This sort of activity will make your career path effortless as you will enjoy the work you do every day. Find your specialty in your favorite's area of STEM, and work to prepare yourself to an expert level while developing teamwork skills.

When not working as an astronaut in space her work passions include working in a meaningful supportive role for NASA projects through experiment testing and procedure review of

International Space Station and Orion Programs. The work is varied as some days there's lots of managerial tasks and some days you can practice space walks in the world's largest space zero buoyancy simulation pool at the Johnson Space Center.

The process of astronaut application and training was explained along with some top tips to increase your chances for becoming an astronaut class candidate. Advice included a passionate high interest level in all aspects of STEM as well as an expertise with languages, especially Russian due to the US and Russian partnerships with Soyuz and ISS.

We thank Stephanie for answering our Vaughn College student question related to robotics in the future space exploration. Robotics was mentioned as a vital tool as we work in our return to the moon and shoot forward to Mars our Martian Robotics missions are the precursory missions to better understand the Martian environments to drive human missions Of course the robotic arm technology used on the space shuttle and space station has been a vital tool in orbital construction. Further to this, robotics will be an asset in the future construction of Gateway Station for Moon missions and beyond.

Industry Connection Seminar

Tuesday, March 23, 2021
11 a.m. to 12 p.m., A Zoom Virtual Seminar

Presenter: Mr. Carlo Asaro, Aircraft Avionics Systems Engineer with Sikorsky, a Lockheed Martin Company
Topic: Electrical Safety and Consideration

Carlo Asaro is a senior aircraft electrical and avionics systems engineer for Sikorsky and an adjunct faculty at Vaughn College. His industry experience on high profile military aviation projects gives him a great deal of insight to draw from when working with our students. This level of engagement was demonstrated on Tuesday March 23rd when Carlo addressed the Vaughn community as part of the College's Virtual Industry Connection Seminar series on the topic of Electrical Safety Considerations.

The presentation started with an image of a breadboard prototype where Carlo briefly explained the development of prototype electronic circuit boards where military grade components are used to test out designs. All the components are hand soldered in a rough state with revisions handled through the addition of bodge wires to revise design as required. Once the design is verified as working in the bread board state a printed circuit board layout is developed using CATIA and sent out to a local PCB board production facility. Decommissioning of designs was also discussed as certain products contain sensitive intellectual property and must be destroyed or confiscated by the military to respect security concerns.

The overall underlying topic of the presentation was safety first. The serious nature if the topic was addressed by discussing some tragic workplace accidents related to servicing motors accidentally left in a powered-on state. Personal electrical safety equipment such as probes, high voltage resistant gloves, and foot pads were shown as effective measures against fatal injuries. The topic of proper electrical shielding and grounding was also explored as a method to prolong the life of electrical systems in the field. Maintenance issues and the importance of regularly scheduled inspections and service on electrical motors was briefly explained. Special focus was given to the concept of proper motor case work and shielding for extreme environments such as fuel pumping stations, and underwater operating conditions. At the end of the presentation a Q and A session allowed students and instructors to attain some inside knowledge regarding best practices and standards related to safety concerns.

We thank Mr. Carlo Asaro for sharing with the Vaughn College community and hope he can further develop some insightful presentations for our industry connection seminars.

Industry Connection Seminar

Thursday, April 15, 2021
11 a.m. to 12 p.m., A Zoom Virtual Seminar

Presenter: Ms. Loretta Alkalay, Aviation attorney and Adjunct Professor
Topic: Update on new FAA drone Rules that go into effect April 2021

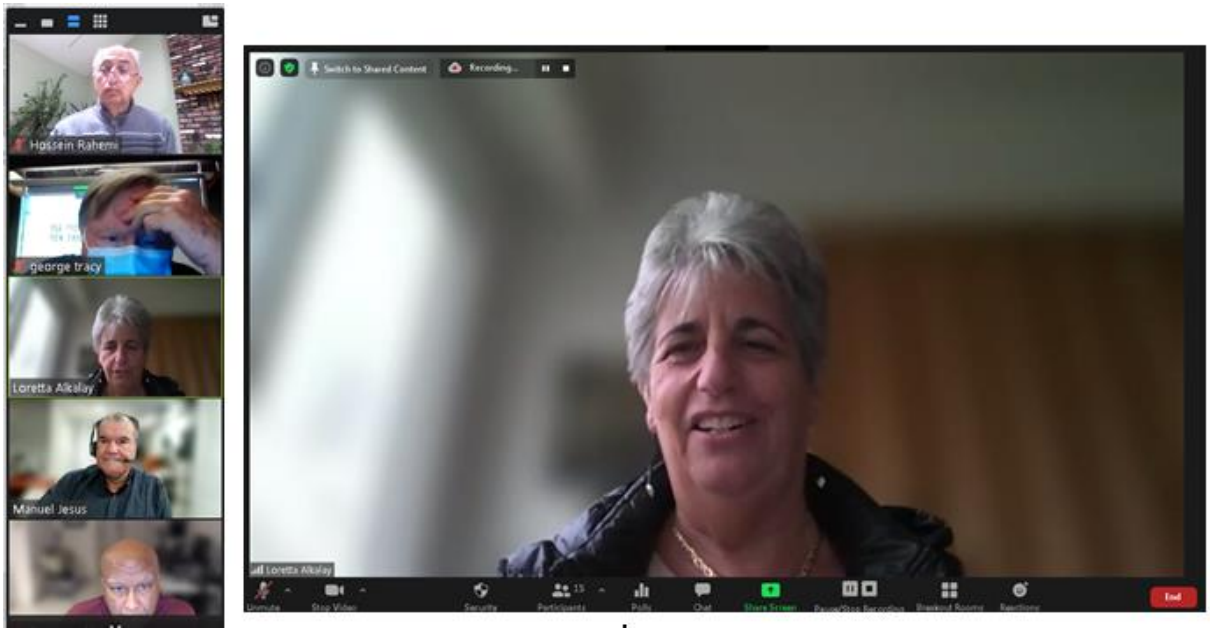
On Thursday April 15 from 11 am to 12 pm as part of the College's Industry Connection Seminar and Management Speaker Seminar series, Ms. Loretta Alkalay, an aviation attorney, specializing in issues related to compliance with federal aviation regulations, including drone rules and an adjunct professor at Vaughn College updated Vaughn community on new FAA drone rules that go into effect April 2021, including operations over people rule and remote ID rule. Her presentation on FAA new Drone Rules covered the burgeoning field of UAV with special attention on operations over population centers, night flying, and remote ID.

This was our last presentation of the season and the topic was of interest to students from both the hobbyist standpoint and serious academic study. Vaughn College students have always been early adopters of this technology. As an instructor, friendly conversations with students eventually trail off into aviation related topics and drones are always at the top of the list. Whether you talk to a student with military drone experience, a weekend hobbyist, or a UAV club member, its clear low-cost drone hardware offers a tangible and safe gateway into the world of aviation.

We received Loretta's presentation with anticipation due to the high level of passion regarding the topic by both students and faculty. At the end of the presentation one key takeaway was that FAA drone related policies developed today will have lasting ramifications in the future. Although a disclaimer was given to remind attendees that the presentation was an overview of rules and not legal advice, one cannot ignore Loretta's long list of aviation related legal credentials with the FAA and aviation legal firms. So, it was within this framework that presentation was delivered and it became clear that there is lots of room for interpretation of the rules that may result in future litigation.

The new regulation changes to part 107 are effective April 6th and on a positive note, drone operators do not have to take an in person recurrent test. The $160 test fee has been replaced with free online recurrent training. Unfortunately, consumer products drones within the category 1 operations regime must now weigh .55 pounds or less and sustained flights over open air assemblies are prohibited. This regulation extends to hobbyist builders and students. Remote ID was discussed with mandates to implement RID across all models however drones without the remote ID equipment can operate at FAA Recognized Identification Areas (FRIAS). The new FAA controlled drone ID system must broadcast a unique drone ID including drone position, altitude, takeoff location, elevation, and time stamp. Although manufacturers have 18 months from April 21st to comply with the new rules, some manufacturers such as DJI state they can implement the RID requirement through a software update.

The presentation ended with a question-and-answer session about the ramifications of these new standards in industry. It was clear the rules described were designed to protect human life and safeguard operations in both the hobbyist market and professional transportation industry. With this strong set of regulations in place the aviation drone market has more mandates in place inspire growth while ensuring safety.



Vaughn's 6th Annual Manufacturing Day, Virtual Conference and STEM Workshops October 30th 2020, 10 am to 2 pm

Leadership Session of Manufacturing Day Conference – Presentation of Industry Leaders

The Engineering and Technology department hosted its 6th Annual Manufacturing Day Virtual conference on Friday October 30th to celebrate National Manufacturing Day. Vaughn College invited five industry leaders and one faculty members to address invited guests and the Vaughn community about manufacturing innovation in the area of AM Journey to Production, Industry 4.0 Part II, Drone Manufacturing and ISO Manufacturing Standards, Digital Manufacturing and the IIOT: Success with a Single Platform, additive manufacturing for aerospace, and additive manufacturing with consumer grade low cost 3D printers.

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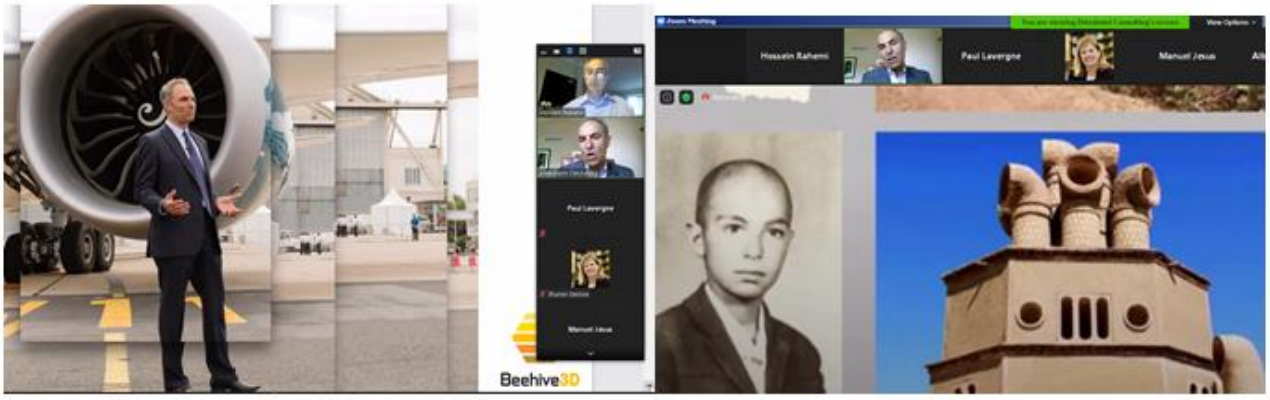
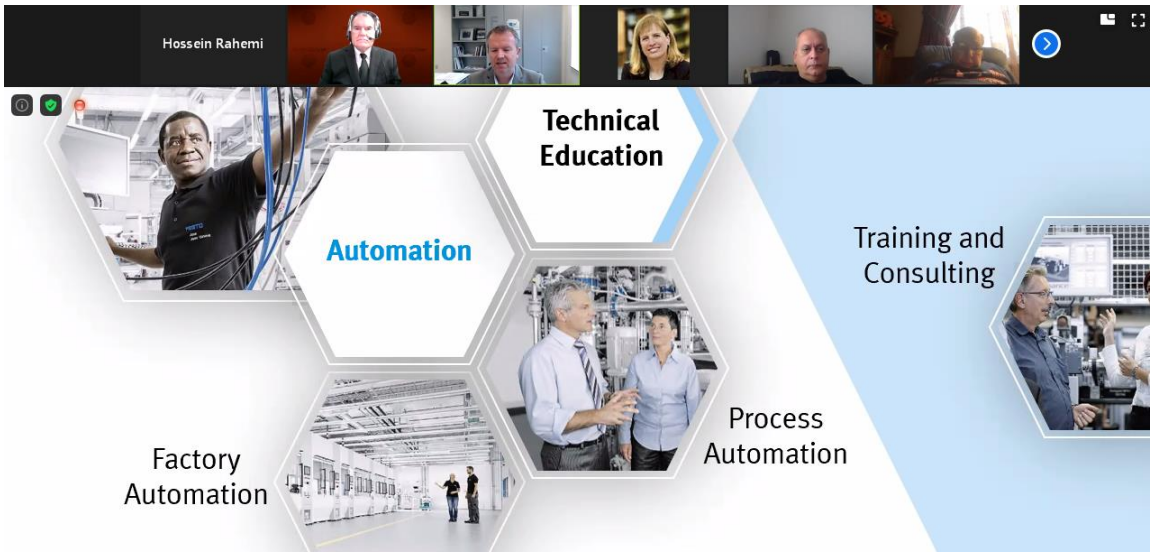
Mohammad Etheshami, President and CEO of EEC,
Retired President and CEO, GE Additive
Topic - GE Additive Manufacturing, AM Journey to Production

Mohammad delivered a presentation focused on General Electric's pioneering use of additive manufacturing. He discussed his leadership and key role in taking GE's AM division from a startup division to world leader in the field. Special focus was given to GE's expertise in part consolidation of complex assemblies to single part AM metal fabricated solutions resulting in impressive material and cost savings. At the end of the presentation Mohammad gave valuable insight into his cultural background as an immigrant and how one should always strive for excellence. This was inspirational as many Vaughn College students share a similar background with Mr. Eteshami.



Tony Oran, Vice President of Sales, FESTO
Topic - Industry 4.0, Part Two
In the second part of his industry 4.0 talk Tony's focus centered on challenges faced in manufacturing during the covid-19 pandemic. The discussion elaborated on how industry 4.0 processes can ensure a smooth transition back to domestic manufacturing. Special focus was given to the concepts of synergistic networking of people, products, and machines to deliver manufacturing solutions in a modern-day supply chain that breaks over dependence on Far East manufacturing.



Peter Kalatzidis, Evaluation Team Leader Engineer, Easy Aerial
Topic - Drone Manufacturing with ISO 9001 Standards
Peter Kalatzidis is a Vaughn College Mechanical Engineering Program Graduate and an employee of Easy Aerial in Brooklyn NY. He spoke about the importance of respecting ISO standards related to drone manufacturing for international clients. Systems organization through naming conventions, and versioning were discussed as essential methods to respect part revision history in the production process. Peter also reflected how his experience with Vaughn College project management, club activity, and CAD courses prepared him for work in industry.

Prashanth Mysore, Director, Global Strategic Business Development and Industry Marketing, Dassault Systems
Topic-Digital Manufacturing and the IIOT: Success with a Single Platform

Prashanth spoke about the use of CATIA 3DExperience as a valuable one stop tool to develop factory workspaces. Dassault's premiere PLM solution empowers the user through synergy of CAD datasets, engineering data, and workflow planning to optimize the manufacturing process from the ground up. The 3DExpereince platform integrates the total product lifecycle management process using one solution for all aspects of manufacturing. During the initial phase of the pandemic Vaughn College adopted 3DExperience as a supplemental way to run CATIA V5 as a rich app on the cloud so this presentation offered valuable insight to the full scope of possibilities using 3dExperience.

Alex Devon, Proto Labs

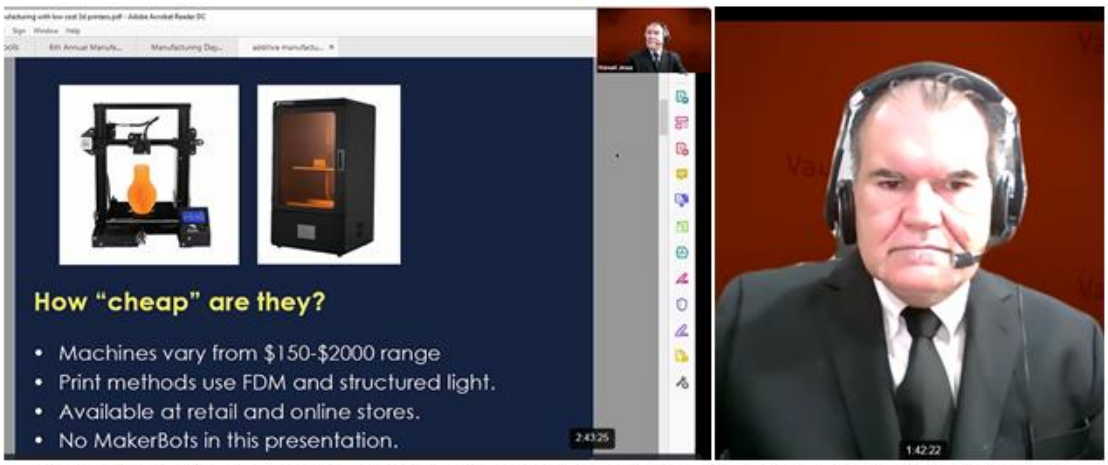
Topic - Additive Manufacturing for Aerospace

Alex Devon of Proto Labs spoke about the services offered by Proto Labs and additive manufacturing domestic outsourcing partner with tremendous experience in all aspects of additive manufacturing. All the current additive manufacturing methods are offered as a service by Proto Labs. He also spoke of the unique opportunities for students to improve their skillsets for tasks such as part consolidation, design for AM, and creative thinking.

Prof. Manuel Jesus, 3D/CNC Curriculum Designer, Vaughn College

Topic - Additive Manufacturing with Low Cost Consumer Options

Manuel presented an overview of consumer grade additive manufacturing machines. The presentation was a buyer's guide for students looking to acquire a machine for use in the home. Current generation machines offer great advantages though lower cost of ownership achieved by easily sourced replacement from Amazon.com. Both FDM and Photopolymerization were covered as high-resolution 3D printing options for the home and small office.



Leadership Session of 2020 Manufacturing Day Virtual Conference

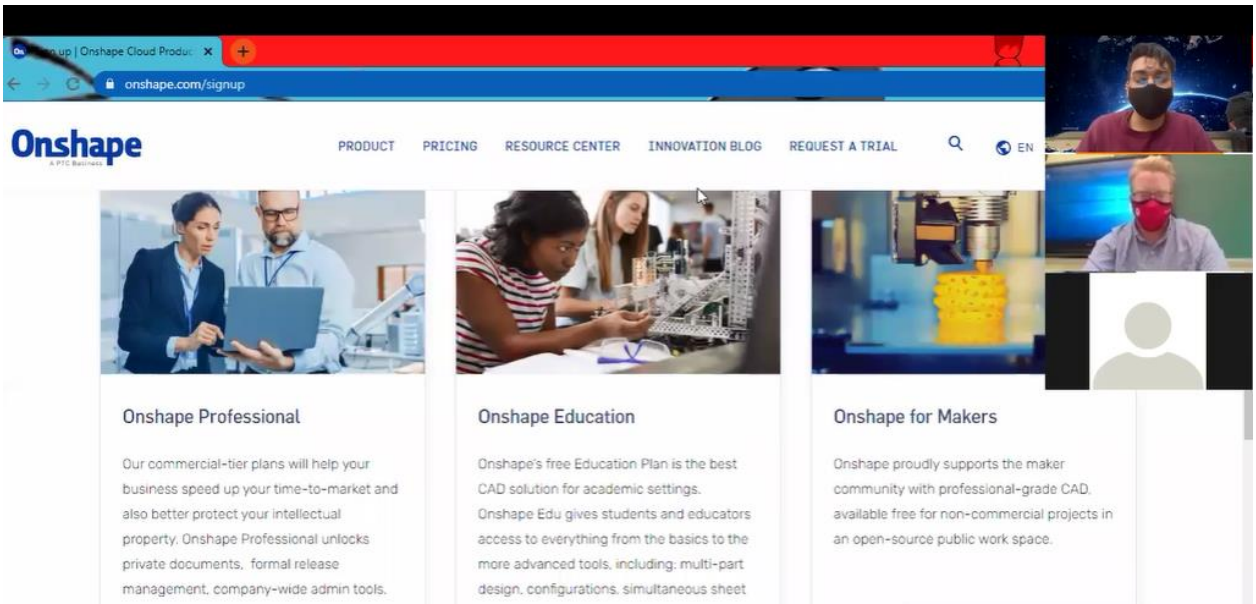
In conclusion, Dr. Rahemi, expressed his sincere gratitude to all guest speakers, industry advisory members, and invited guest for their participation at Vaughn's 6th annual manufacturing day conference as well as their continuous support in every aspect of the department and institution. Dr. Rahemi expressed we are thankful for the support provided by the Department of Education federal fund as part of Title III, Part F, HSI-STEM and Articulation grant. .

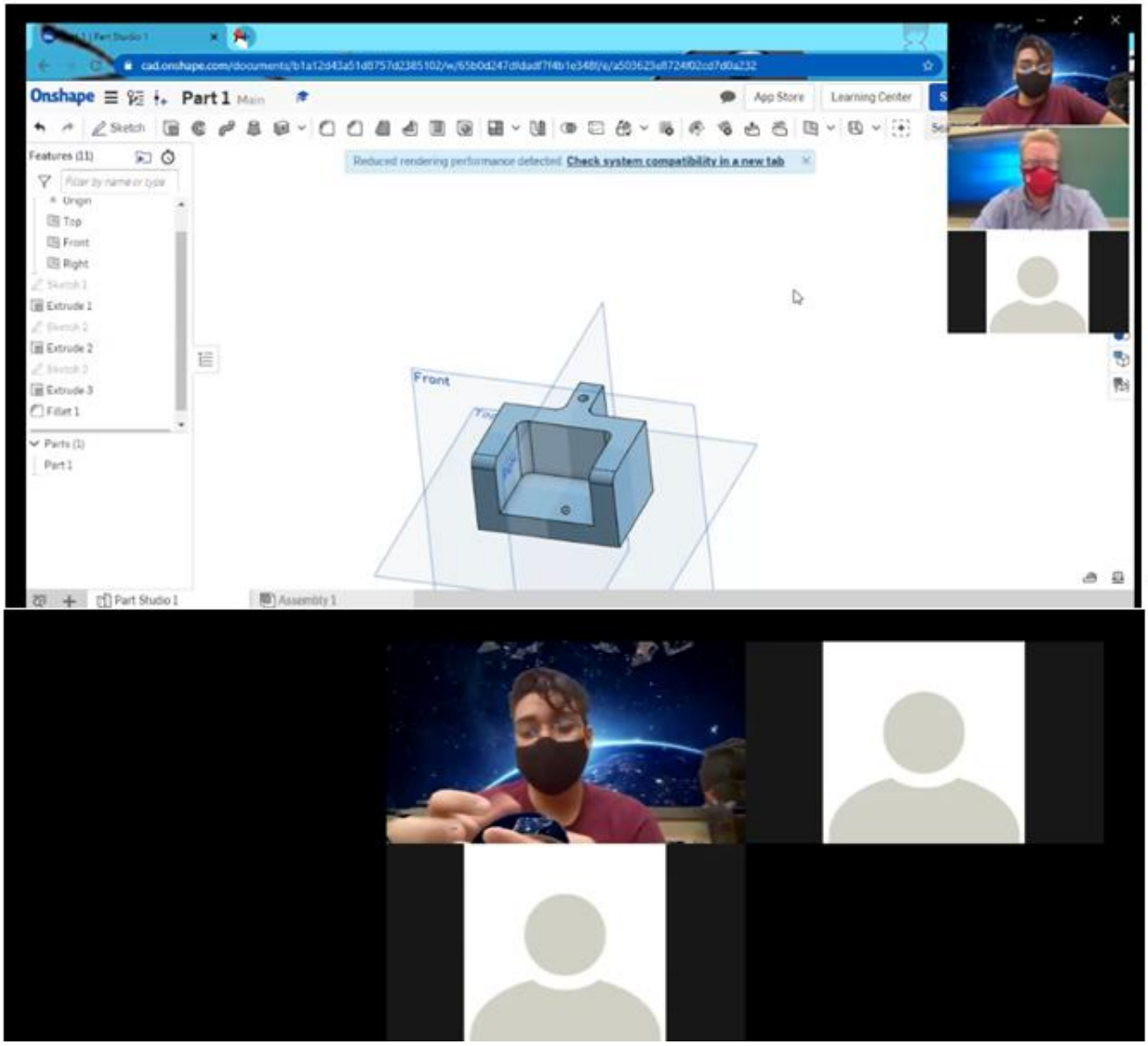
STEM Outreach Workshops

In a parallel session, from 10 am to 12:00 pm, Vaughn's UAV, Robotics, and SWE clubs organized and hosted STEM workshops for the high school students. These workshops covered following items

1. Robotics Workshop - Robotics design & autonomous programming for the VEX Robotics Competitions
2. An informational session about the basics of drones and the design considerations
3. Drone Autonomous Programming using Mission Planner software.

The robotics club conducted a workshop related to robotic design using SolidWorks and instructed students in the structural design process necessary for the creation of a robot that will perform quickly and accurately during a competition. These Virtual Workshops Sessions were conducted through Onshape software.





CAD, Drone and Robotics Workshops Session

Vaughn's STEM Day Virtual Workshop
April 9, 2021, 10 am to 12 PM

The engineering and technology department hosted its third Annual STEM Day virtual workshop event for community colleges and high schools students on Friday April 9.

This virtual event introduced participants to the following STEM related activities

- **Welcome:** A presentation of Vaughn College's program offerings and student involvement in professional and scholarly activities.
- **Makerspace and CNC Video Tour:** In this session participants were introduced to a virtual tour of Vaughn's 3D Makerspace and CNC centers as well as their usage and hands-on application in STEM related programs.
- **3D Scanning Workshop:** In this session participants were introduced to reverse engineering parts from 3D Scan data using CATIA.
- **CAM and CNC Workshop:** Participants were introduced to HASS VF-2SS CNC and cutting machine, Okuma lathe machine, Coordinate Measuring Machine (CMM), and manufacturing processes. For this session, STEM liaison showed a video of a part development and details of manufacturing process using CNC milling, lathe, and CMM.
- **Virtual Reality:** In this session, participants were introduced to the world of Virtual Reality (VR) and simulations. For this session, participants learned about the VR usage and application by Vaughn's UAV club and institution plan is to further expand and include VR application as part of Vaughn's NYSED approved UAS certificate program.
- **Student STEM Engagement:** Introduction to student engagement in technical clubs, competitions, conference participation, presentation and publications. For this session, participants were introduced to a presentation by Vaughn's UAV, Robotics, and Rover clubs.

The participants of Vaughn's STEM Day virtual workshop event were students and faculty from Passaic CC, Queensborough CC, Bergen CC, Aviation High, and Humanities & Arts high school. For this virtual events, Vaughn's STEM Liaison and 3D/CNC curriculum developer, Prof. Manuel Jesus, introduced participants to Vaughn College's program offerings in engineering and engineering technology disciplines as well as student involvement in various STEM related clubs and professional activities. Prof. Jesus, provided participants with a video tour of Vaughn's 3D Makerspace and CNC manufacturing centers. Finally, he organized and hosted couple of virtual STEM workshops related to 3D Scanning, CAM and CNC, and Virtual Reality.

Virtual Makerspace and CNC Lab Tours: For this virtual event session, Prof. Jesus, provided audiences with a video tour of Vaughn's manufacturing centers and through this video tour, he discussed these centers are used by Vaughn's students and faculty to design and manufacture parts and components for their class and capstone design projects. He added, these centers are actively used by Vaughn's clubs' students to manufacture parts for their robots, drone, and rover projects. Finally, he emphasized that the engineering department with assistance of manufacturing Lab Techs use these centers to host STEM workshops for community colleges and high schools students during Vaughn's Annual Manufacturing Day, Annual STEM Day, and Vaughn's International Drone Day.

Student STEM Engagement and Technical Clubs Presentations: Vaughn's UAV, Robotics, and Rover Clubs leaders talked about their experiences and after-class involvement in professional clubs and technical competitions as well as their conference participation, presentations, publications, and accomplishments in STEM fields. They emphasized how involvement in both technical competitions, student chapter of professional societies, and conference participation helped them to get several internship offers as well as full-time positions with well-known engineering companies.

Acknowledgement: In conclusion, Dr. Rahemi, thanked all partner institutions for their participation and expressed his sincere gratitude to the Department of Education federal grant (Title III, Part F, HSI-STEM and Articulation grant) which provided necessary funding support for laboratory development to engage students in manufacturing hands-on activities that are current with today's industry standards. .

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Vaughn's UAV team participated in the Vertical Flight Society Virtual Design-Build-Vertical Flight Competition, April, 16 2021

Vaughn's UAV team project was selected as one of the finalists along with Penn State, Ohio State, Oregon State, University of Michigan, and University of Maryland to participate in the Design-Build-Vertical Flight Competition in Graces Quarters Army Test Site, Maryland. Vaughn's UAV Team developed a drone to compete in both the manual and autonomous categories. The drone was designed to perform vertical takeoff & landing (VTOL) with onboard flight-stabilization and camera. The drone's weight was less than 2lbs fully built and had a lift capacity of 12lbs. The drone successfully flew through an obstacle course while avoiding objects and having 10lbs of payload onboard. Vaughn's drones are designed to be lightweight and compact, while not sacrificing their autonomous, computational, and flying control.

For both the autonomous and manual challenges, a drone with a pre-determined package will take off from a base station, move through an obstacle course, and execute three vertical takeoffs and landings for the maneuverability course. For the flight duration, the drone will take off and fly a course as many times as it can before having to land due to low power. This tests the drone's endurance as well as range capabilities. Among all participating teams, Vaughn College was recognized by Boeing for having a compact design and being able to have a great lift capacity with the given design. Boeing was particularly interested in the use of our 90° bore clamps to create a 3x3 square giving the drone self-supporting elements. For the autonomous section, Vaughn's autonomous team was able to fly their drone with vertical takeoff and hovering using code developed over the years through Ubuntu and MAVProxy. Due to Covid-19, this year competition was postponed and moved to a virtual design competition.

On Friday April 16, Judges from the aerospace industry evaluated teams' performance for both the remote and autonomous control categories. Among the judges, Boeing and Aerojet were in attendance to view the many designs; teams from across the country had to offer for Urban Environment Maneuverability (UAM). Five members of the Vaughn College UAV team (Jairo Andrew Ramos, Nicolas Bentancur, Kiran Boodhoo, Yusuf Rafi, Kevin Gonzalez) were all part of the 2021 VFS Design-Build Vertical Flight competition.

Virtual presentation of Vaughn's UAV team about their drone design approach

Vaughn's Engineering Faculty and Students Participated in LACCEI2020 Virtual Conference; Vaughn's Students Take First Place for both paper and poster session competitions of 2020 LACCEI conference.

From July 27-31, Vaughn's engineering and technology students, along with Dr. Hossein Rahemi, engineering department chair, attended the LACCEI 2020 Virtual Conference. Three Vaughn student team research papers were accepted for presentation and publication in the LACCEI 2020 international conference; Three Vaughn student papers as listed below were selected to compete among ten finalists for the student paper session, and two submitted papers were accepted for the poster session of LACCEI 2020 as well.

Finalist For LACCEI Paper Session

1. "Autonomous Medication Distributor Through Implementation of Bresenham's Line Algorithm" by Brandon Duran, Diego Villegas, and Sebastian Valencia
2. "Modular Torque Wrench Extension with Heads-up Display" by Atif Saeed, Juan Aguirre Rodrigues, and Juan Castano
3. "Development of an Advanced Robotics Program for Middle and High School Vex Robotics Students" by Ryan Tang Dan and Maharshi Patel

From 11 am to 1 pm on Tuesday, July 28, three of our student team papers as listed in above were presented to the international conference audience during the student paper session of LACCEI 2020.

Brandon Duran's, Diego Villegas', and Sebastian Valencia's paper addressed the design and development process of an **Autonomous Medication Distributor**. Their paper and presentation detailed the development process of an autonomous system that dispenses pills of various sizes and shapes. The overall objective is to utilize the invention to assist in dispersing the appropriate amount of medication for prescribed patients at designated times.

Atif Saeed's, Juan Aguirre Rodrigues', and Juan Castano's paper and presentation covered design, development, and manufacturing process of **Modular Torque Wrench Extension with Heads-up Display**. The objective of their project is to design a compact, affordable, and precise torque wrench extension with heads-up display. Their product aims to provide modularity between a varity of ratcheting wrenches and to allow the user live torque feedback displayed on safety glasses, in order to reduce the likelihood of a fastening error. Judges selected their paper as a **first place award recipient** in the 2020 LACEEI student paper session competition.

Ryan Tang Dan's and Maharshi Patel's paper outlined a project idea of creating an Advanced STEM program that improves the competition outcomes of first-year middle and high school students in the VEX Robotics competition. The program consists of three semesters based on the New York State competition season, engineering design process, and individual team progress. The STEM program also includes simplified college-level courses such as engineering math, physics, kinematics, dynamics, as well as advanced courses such as control systems and PID tuning.

The First Place Winners of the LACCEI 2020 Student Paper Session Competition "Modular Torque Wrench Extension with Heads-up Display." by Atif Saeed, Juan Aguirre Rodrigues, and Juan Castano

Virtual LACCEI 2020 Poster Competition

From 2:30 pm to 4:30 pm on Wednesday, July 29, two of Vaughn's student team posters were selected for the LACCEI 2020 Virtual poster session competition. Vaughn's student poster by Ryan Tang Dan and Maharshi Patel outlined **Development of an Advanced Robotics Program for Middle and High School Vex Robotics.** Their poster presentation provided insight into a STEM program that improves the competition outcomes of first-year middle and high school students in the VEX Robotics. The second Vaughn student poster by Brandon Duran, Diego Villegas, and Sebastian Valencia outlined their degree capstone project **"Autonomous Medication Distributor through Implementation of Bresenham's Line Algorithm".** Their presentation provided insight into their design and development process for the autonomous medicine dispenser that creates a cost-efficient and reliable alternative product for patients to use for their medical needs. Judges selected their poster as a **first place award recipient** in the 2020 LACEEI student poster session competition. .

The First Place Winners of the LACCEI 2020 Student Poster Session Competition "Autonomous Medication Distributor through Implementation of Bresenham's Line Algorithm." by Brandon Duran, Diego Villegas, and Sebastian Valencia

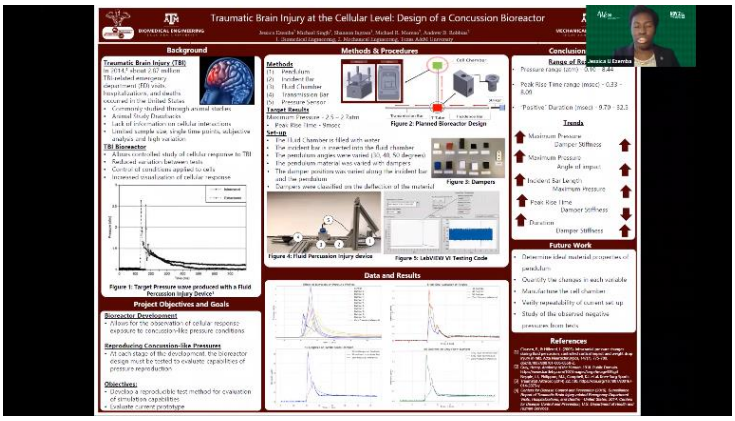
Women Engineering Conference 2020

The Vaughn College chapter of the Society of Women Engineers (SWE) attended the 2020 Women Engineers Conference virtually from November 2nd through November 13th, 2020. During the conference, ten members of the chapter had the opportunity to attend leadership seminars and technology talks. In addition to attending seminars, SWE students attended the career fair, and they received interviews with industry leaders such as Johnson & Johnson, Stryker, Medtronic, Blue Origin, Northrop Grumman, Ball Corporation, Air Force Research Laboratory, Boston Technology, Siemens AG, Jacobs Engineering Group Inc., and Southwest Research Institute.

The overview of the success of WE20 Conference

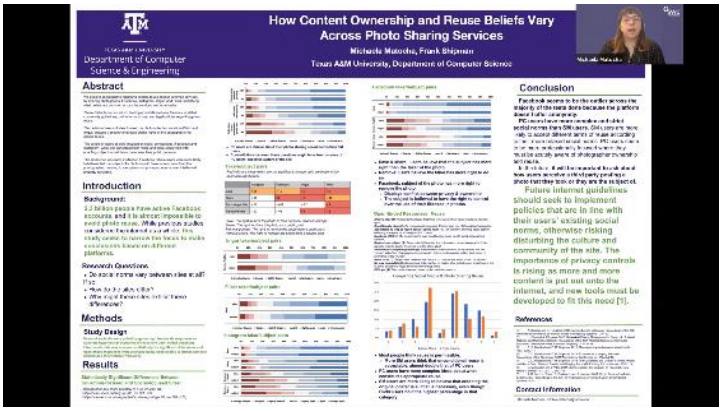
Name	Company	Full-time Offer	Internship Offer
	Johnson & Johnson	Yes	
	Stryker	Yes	
Maharshi Patel	Medtronic	Yes	
	Blue Origin		Pending
	Northrop Grumman		Pending
Tatiana Jaimes	Ball Corporation		Pending
	Air Force Research Laboratory		Pending
	Boston Technology		Pending
August Rodriguez	Southwest Research Institute		Pending
	Siemens AG		Pending
	Medtronic plc		Pending
Alina Santander	Jacobs Engineering Group Inc.		Pending

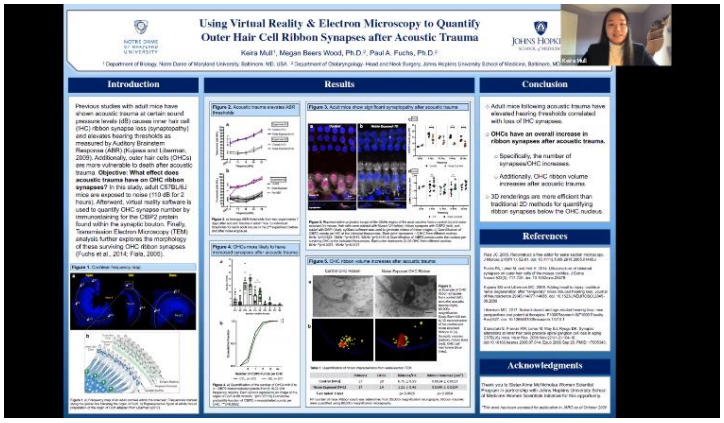
Seminars



SWE-VCAT vice president, Maharshi Patel attended several seminars in biomedical engineering. This talk sheds a light on the effects of traumatic brain injuries at the cellular level.

SWE-VCAT members attended several career readiness seminars. These seminars highlighted the proper uses of social media and proper uses of imaging to boost participants' career opportunities in STEM fields.





SWE-VCAT president, Alina Santander and Secretary, Tatiana Jaimes, attended the Undergraduate Student Poster Competition. This session highlights 10 student poster presentations.

Virtual Career Fair

It is important to highlight the virtual format of this year's Career Fair. In addition to the different workshops and seminars, members were able to connect and chat with recruiters, and learn more about opportunities that those different companies offered for our students.

Acknowledgement: We are thankful to the Department of Education federal grant (Title III, Part F, HSI-STEM and Articulation grant) which provided necessary funding support to engage Vaughn's students in STEM related scholarly and professional activities.

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2020 Society of Hispanic Professional Engineers (SHPE) National Conference, October 26 to October 31, 2020

From October 26 to October 31, 2020, a group of eight Vaughn College engineering students virtually attended the 2020 Society of Hispanic Professional Engineers (SHPE) Conference. Vaughn's students took part in a design competition as well as a variety of professional development workshops aimed at promoting teamwork, unity, and exposure to a variety of STEM career options.

Cummins, Ford, Aerotek, Huntington Ingalls Industries, Pratt & Whitney, Collins Aerospace, GM, Raytheon, Toyota, John Deere, among other companies interviewed Vaughn's students resulting in 10 interviews among the eight students.

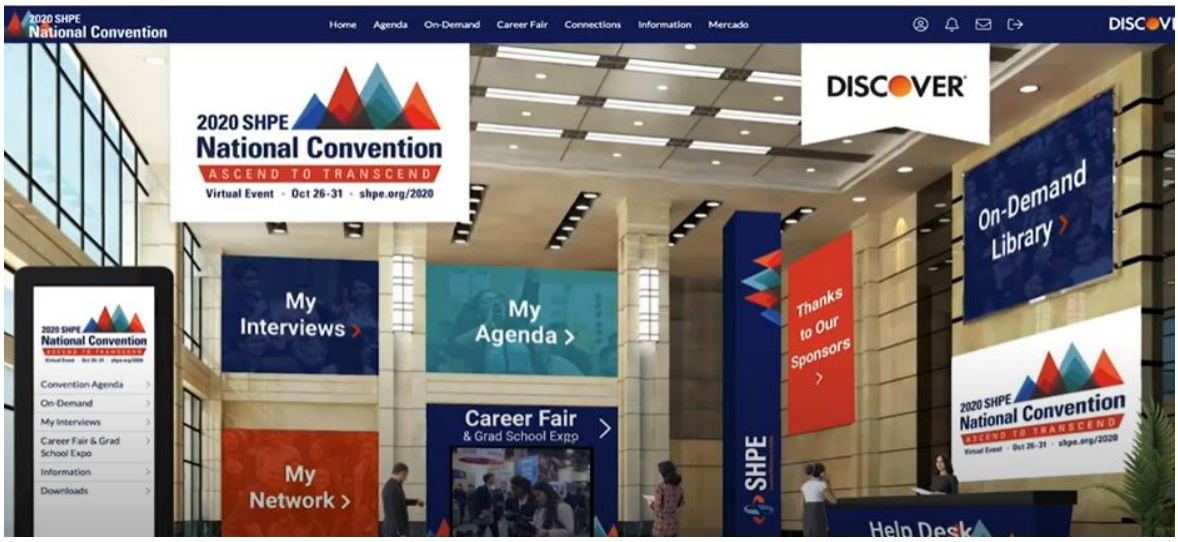
VC-SHPE Chapter National Conference Attendees

Attendee's Name	Engineering Program	Academic Year	Industries Applied To
Manolo Duenas	Mechatronics	Senior	Manufacturing Systems
Cesar Valle	Mechanical	Senior	Industrial Automotive
Mariah Villalon	Electrical	Sophomore	Supply Chain and Logistics
Ricardo Tomala	Mechatronics	Sophomore	Product Development
Kastrinepaul Thevasahayam	Mechanical Technician	Senior	Quality and Reliability
Kastronepaul Thevasahayam	Mechatronics	Senior	Product Development
Tatiana Jaimes	Mechanical	Sophomore	Human Factors & Ergonomics
Aaron Arana	Mechatronics	Senior	Quality and Reliability

For the 2020 SHPE National Convention, the VC-SHPE Chapter had the opportunity to professionally prepare eight diverse attendees to represent Vaughn College competitively in all aspects available by the convention. These attendees differ from one another not only by the Engineering program in which they are enrolled, but also by their academic year and the industries to which they applied.

VC-SHPE Chapter Engineering Challenges Accepted Attendees

Attendee's Name	Engineering Competition	Competition Contribution
Manolo Duenas	Innovative Challenge	Prototyped an App, with the purpose of using a LIDAR sensor to map the room surrounding blind users and analyze data collected through Artificial Intelligence
Ricardo Tomala	Innovative Challenge	Prototyped an App, with the purpose of locating and registering users to nearby hospitals based on their medical assistance desired. The app also provides waiting times before being attended and updates on results for tests taken by the hospital.
Kastronepaul Thevasahayam	Engineering Science Symposium	Researched and presented a paper following ASME format, focusing on the fundamental advances and application of Artificial Intelligence
Tatiana Jaimes	Innovative Challenge Extreme Engineering Challenge	Coordinated an executive summary, financial statement, marketing strategies, and the means to expand and perfect a prototyped App, with the purpose of augmenting virtual reality to further secure safety for users while online shopping. Coordinated Statistical Data Collection and Research supporting the feasibility of a virtual city in which users can input CAD design and simulate the Environmental Impact of their infrastructures.
Aaron Arana	Innovative Challenge	Collected medical databases and drew a data table of conditions and diseases with similar symptoms, to be used with a machine learning program.



All our attendees applied to participate in the Engineering Challenges, and several of them were accepted. The attendees faced similar challenges within the individual diverse competitions. Two of our accepted members had the opportunity to become finalists within the Innovative Engineering Challenge and Extreme Engineering Challenge. These challenges are a critical event within the convention and being recognized by recruiters and judges contributed to the technical, professional, and troubleshooting skills of our attendees.

VC-SHPE Chapter National Conference Post-Career Fair Success

FULL NAME	MAJOR	COLLEGE	COMPANY INTERVIEWS	OFFERS
Manolo Duenas	Mechatronics	Senior	BAE Systems	Pending
Cesar Valle	Mechanical	Senior	GM	Pending
Mariah Villalon	Electrical	Sophomore	DuPont	Pending
Ricardo Tomala	Mechatronics	Sophomore	North Grumman	Pending
Kastrinepaul Thevasahayam	Mechanical Technician	Senior	Honeywell	Pending
Kastronepaul Thevasahayam	Mechatronics	Senior	Medtronic	Pending
Tatiana Jaimes	Mechanical	Sophomore	BP America	Pending
Aaron Arana	Mechatronics	Senior	Texttron	Pending

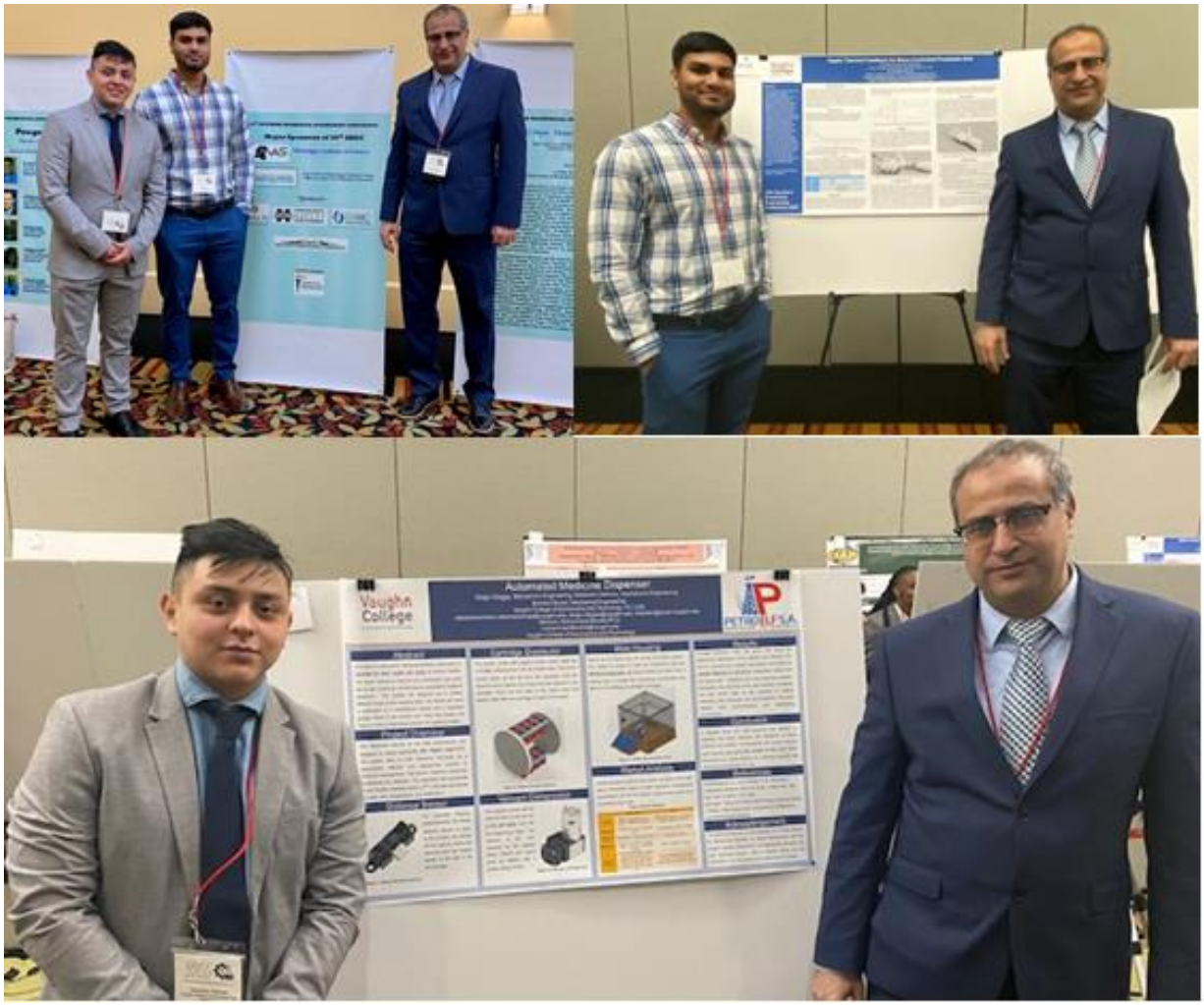
For this year's National Convention, the attending members had a total of 12 interviews by the following STEM leading companies; BAE Systems, G.M, DuPont, North Grumman, Honeywell, Medtronic, BP America, and Textron. Among those, four resulted in pending Internships and four in potential job opportunities. Although, due to the pandemic, considerably fewer members attended this year's National Convention through our chapter, they were able to conduct approximately the same number of interviews as the preceding year. This shows fundamental progress within our chapter and among our members. SHPE cultivates confidence in our members' abilities to achieve Internships and Job opportunities.

Southern Biomedical Engineering Conference, 36th Annual meeting, New Orleans LA, March 6-8, 2020

From March 6-8, two Vaughn engineering students, Atif Saeed and Sebastian Valencia, along with Dr. Mohammed Benalla, participated in the 36th Southern Biomedical Engineering Conference in New Orleans, LA.

Dr. Benalla chaired a session of Computational bioengineering, Saturday March 7th from 3:00 PM to 4:45 PM, and Vaughn's engineering students Atif and Sebastian had poster presentations on Friday March 6th. The presentations took place between 6:00 PM and 7:30 PM. Atif Saeed presented "Haptic Thermal Feedback Prosthetic Brain-Controlled Arm" and he won the third place award in the undergraduate category, while Sebastian Valencia presented "Autonomous Medicine Dispenser". These two papers were also accepted for publication in the Biomedical Science Instrumentation Journal.

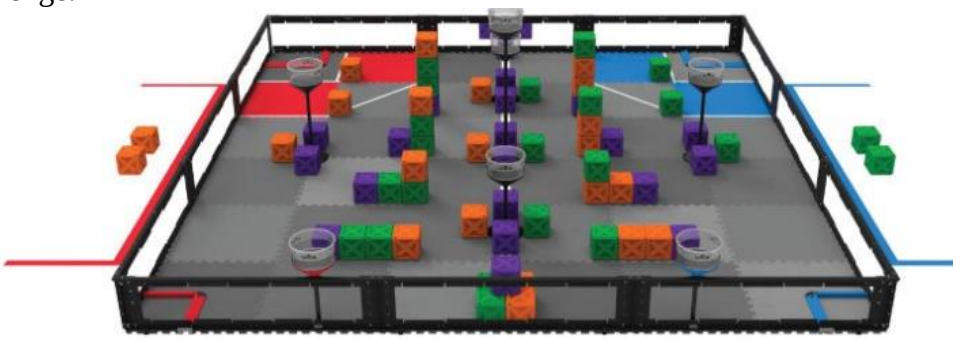
This occasion was a good opportunity for our students to discuss their current projects in public and to receive feedback from biomedical grad and undergrad students, faculty, as well as researchers from different colleges and universities.



2020 VEX Robotics World Championship - VEX U Division
April 25th 2020

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 "VEX Tower Takeover Game." 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. A robot with an effective mechanism to pick up cubes quickly and accurately from any location on the field and place them in towers, or to score stack of cubes in goals.
2. A robot with control algorithms for the best autonomous performance
3. A structurally reliable robot, in compliance with the limitations and constraints of the challenge.



The Game: VEX Robotics Competition Tower Takeover is played on a 12'x12' square field configured as seen above. Two (2) Alliances – one (1) "red" and one (1) "blue" – composed of two (2) Teams each, compete in matches consisting of a forty five (45) second Autonomous Period, followed by a one minute and fifteen second (1:15) Driver Controlled Period. The object of the game is to attain a higher score than the opposing Alliance by placing **Cubes** in **Towers**, or scoring **Cubes** in **Goals**

Scoring:

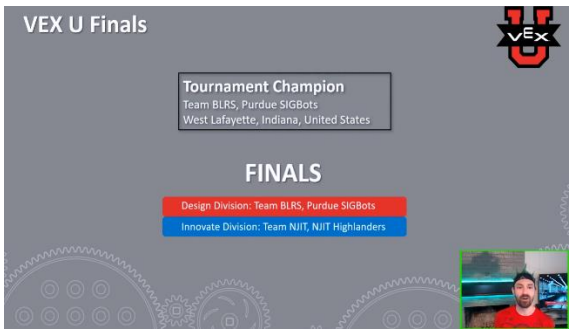
Each Green Cube Scored in a goal	1 point + 1 point for every Green Cube Placed in Towers
Each Orange Cube Scored in a goal	1 point + 1 point for every Orange Cube Placed in Towers
Each Purple Cube Scored in a goal	1 point + 1 point for every Purple Cube Placed in Towers
Autonomous Bonus	6 points
Robot that is Alliance Parked	3 points

The Details: There are sixty-six 66 **Cubes** on a Tower Takeover Field. Twenty-two (22) **Green**, twenty-two (22) **Orange** and, twenty-two (22) **Purple**. There are also seven (7) **Towers** placed around the field. Five (5) of these are neutral, with the remaining two being alliance specific. Alliance specific Towers may only be utilized by robots of the same alliance. Cubes can be **Placed in Towers**, or **Scored in Goals**. Cubes are worth at least 1 point when placed in a Goal Zone. The exact value of each cube is determined by how many Cubes of that specific color have

been placed in Towers. When Cubes are Placed in or removed from Towers, **the new values apply to ALL cubes**. So the actions of one Robot will impact the potential score for both their own alliance and their opponents. The alliance that scores most points in the Autonomous period is awarded with (6) bonus points, added to the final score at the end of the match. The Alliance who wins this Autonomous Bonus is also **awarded 2 purple cubes**, which may be introduced at any time during the driver control period.

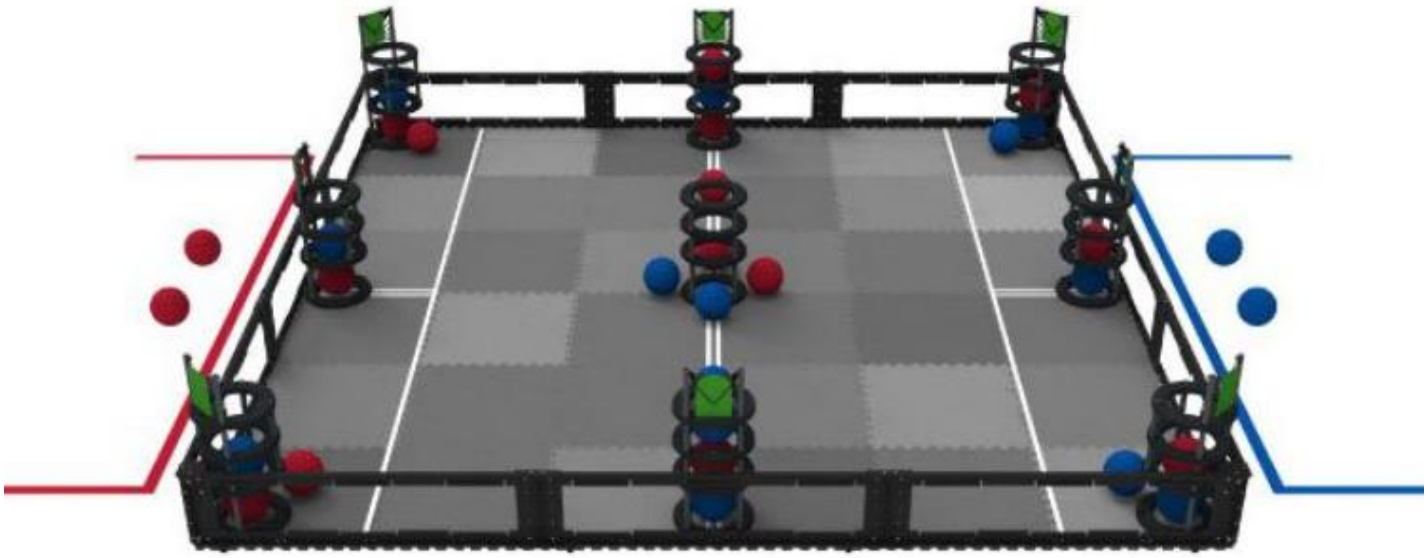
Ninety two national and international universities and colleges from all over the world, such as China, Philippines, Morocco, New Zealand, Canada, and the United States of America as well as Latin American countries received qualification and were invited to the 2020 Virtual VEX U Robotics World Championship. Invitation to the VEX U Robotics World championship is granted only to a team that is a tournament Champion, Finalist or "Excellence" award recipient of a regional competition or who has achieved top place in "Robot Skills". Vaughn's Robotics teams, VCAT1, won both "Robot Skills" and "Excellence" awards of the Vaughn College VEX U Robotics Tournament, and VCAT2 finished first and won 2nd place "Robot Skills" of West Virginia VEX U Robotics Regional Qualifier Competition; thus, both VCAT1 and VCAT2 received automatic qualification to participate in the 2020 VEX U Robotics World Championship.

On April 25th 2020, due to lockdown measures from COVID-19, the World Championship was done remotely through simulated matches. In this event no actual match play was conducted, each match was simulated with the winner of each match chosen based on previous scores from throughout the season. VCAT1 was in the innovate division and ranked 9th out of 46 teams in its division, VCAT2 was in the design division and ranked 17th out of 46 teams in its division. Ultimately BLRS from Purdue University won the Championship. This is the seventh year in a row that Vaughn's team retained their standing as one of the top competitors in the world championship by receiving invitation to this intense and challenging competition.



2020-2021 VEX Robotics Change Up Game: 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 "VEX Change Up Game." 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 a minute and fifteen seconds of driver-controlled manipulation, and a third robot to compete in the skills competition. The team constructed their robots to attain the following objectives:

4. A robot with an effective mechanism that can intake balls to pass through a conveyor belt and be placed at the top of goals.
5. A robot with control algorithms to score and de-score red and blue balls, respectively, for a high skill score and rank.
6. A structurally reliable robot in compliance with the limitations and constraints of the challenge.



The Game: VEX Robotics Competition Change Up is played on a 12'x12' square field configured as seen above. Two (2) Alliances – one (1) "red" and one (1) "blue" – composed of two (2) Teams each, compete in matches consisting of a forty-five (45) second Autonomous Period, followed by a one minute and fifteen second (1:15) Driver Controlled Period. The objective of the game is to attain a higher score than the opposing Alliance by placing **Balls** in **Goals** and **Connecting Rows**.

Scoring:

Each Ball Scored in a goal	1 point for the Alliance corresponding to the Ball color
Each Connected Row	6 points for the Alliance corresponding to the Ball color
Autonomous Bonus	6 points
Completed Home Row in Autonomous	1 Win Point

Game and Scoring Details:

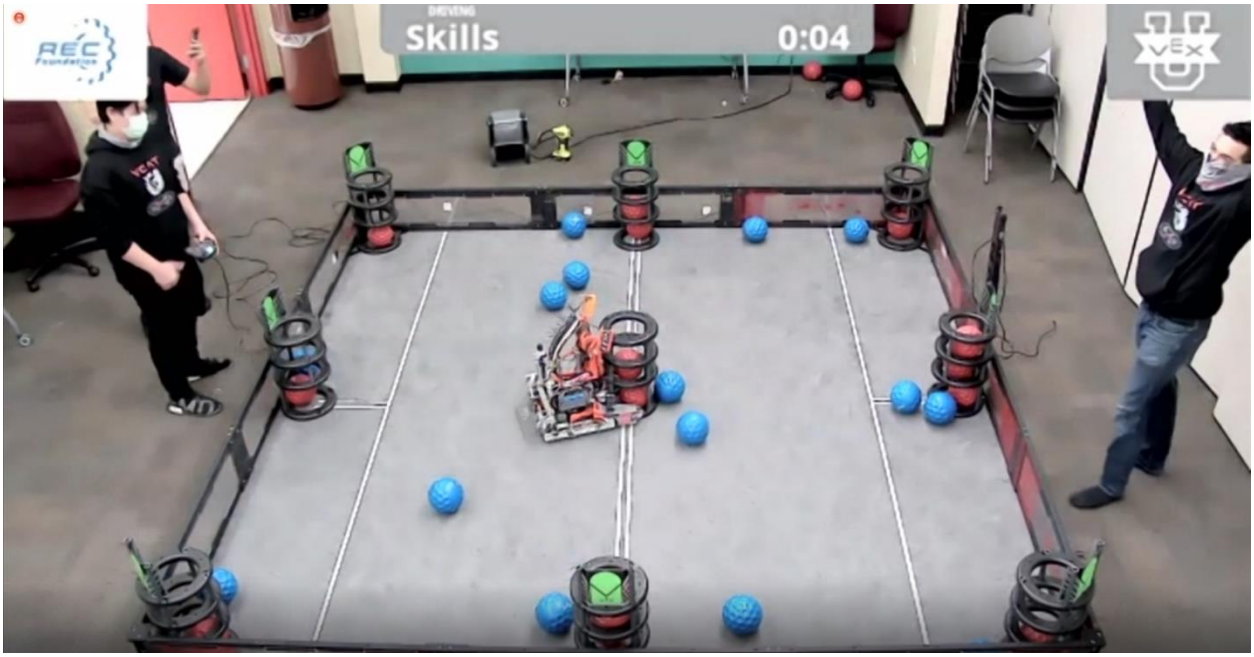
There are thirty-two (32) **Balls** on a Change Up Field, sixteen (16) **Red** and sixteen (16) **Blue**. There are also nine (9) **Goals** placed around the field. Balls are to be scored in **Goals**. Each scored Ball is worth 1 point for the corresponding Alliance color. The highest scored Ball in a Goal will be **owned** by the corresponding Alliance color. If an Alliance owns three goals in any direction (vertical, horizontal, or diagonal), they will receive a 6-point bonus for a **Connected Row**. Nevertheless, Balls can be de-scored by the opposing Alliance at any time during the Driver-Control period. The alliance that scores more points in the Autonomous period is awarded with (6) bonus points, added to the final score at the end of the match. Each Alliance also can earn an additional Win Point by completing their **Home Row** during the Autonomous Period. This Bonus can be earned by both Alliances, regardless of who wins the Autonomous Bonus.

Vaughn College VEX U Robotics Remote Skills Tournament, Saturday, January 16, 2021
Vaughn Robotics Team wins 2021 VEX U Skill Challenge

Vaughn College of Aeronautics and Technology hosted its first VEX U College Remote Skills Robotics competition on Saturday, January 16th, 2021. A total of three college teams participated at this event. The participant teams included New Jersey Institute of Technology (NJIT), TRS Nexus (NXS) and Vaughn College of Aeronautics and Technology (VCAT).

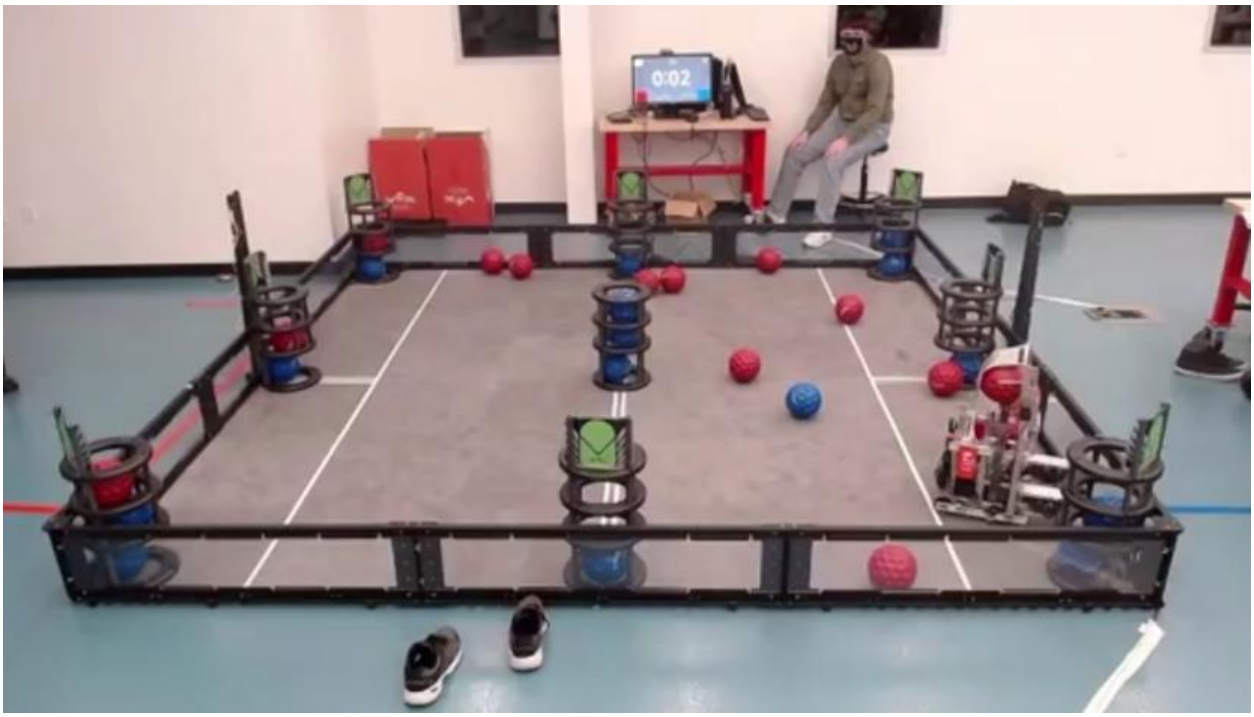
Eight members of Vaughn College robotic club (Manolo Duenas, Tim Tullio, Kevin Tsang, Maharshi Patel, Misael Marquez and August Rodriguez) represented the Vaughn team (VCAT) at this competition. Also, Maharshi Patel served as event manager, and John Sutera served as the live stream operator. Additionally, Kayla Ho of C2C Robotics served as head referee.

During the skills challenge matches, Vaughn's team finished first with total of 204 points in Robot Skills. Each participating team had a total of 3 possible skills attempts (3 programming and 3 driver attempts). Vaughn's team finished first with a programming high score of 78 points and with a perfect driver score of 126 points. Currently, **VCAT team has world first place standing for the Robotics skills.**



VCAT Achieving A Perfect Driver Score

NXS Attempting a Drivers Skills



NJIT Attempting Programing Skills

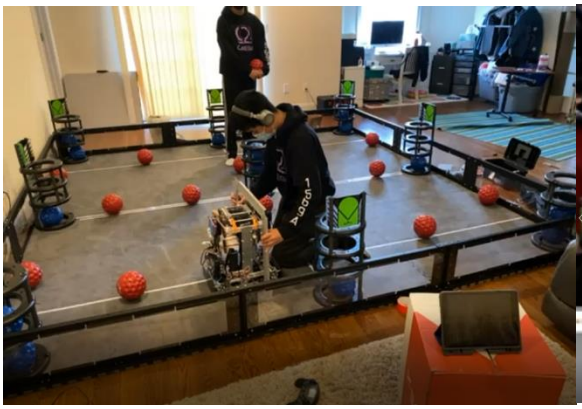
Vaughn College Hosted VEX High School Robotics Qualifier Competition on Sunday, January 17th, 2021

Vaughn College of Aeronautics and Technology hosted its first live remote skills high school robotics competition on Sunday, January 17th, 2021. A total of 9 teams from various locations in the nation, as well as regional high schools from Queens, Nassau, Oneida, King, and Suffolk counties attended Vaughn's 2021 VEX remote skills high school robotics competition. The list of high school participants is as follows:

Team List

Team	Team Name	Organization	Location
8746A	Black Knights	ROME FREE ACADEMY	Rome, New York, United States
38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States
16099A	Overclock	KG Computech	Flushing, New York, United States
16099B	Overclock	KG Computech	Flushing, New York, United States
62880A	Real Steel	C2C Robotics	Bayside, New York, United States
44777U	DiscoBotZ	DiscoBotZ Robotics	Redmond, Washington, United States
16699Y	Overclock MS	NY Youth Tech	Flushing, New York, United States
1569A	OMEGA		Great Neck, New York, United States
62880B	Team Alpha	C2C Robotics	Bayside, New York, United States

The members of the VCAT robotics team organized and acted as referees for the event. Maharshi Patel served as manager and event planner. Kayla Ho of C2C Robotics and Ryan Tang Dan of Overclock served as head referees. John Sutera served as inspector.



High School VEX Robotics Remote Skills Competition, Saturday, January 17th, 2021

The table below provides the list of award recipients for the 2021 high school VEX Robotics remote skills competition. DiscoBotsZ Robotics (Redmond, Washington) won Robot Skills Champion while KG Computech (Flushing, NY) and NY Youth Tech (Flushing, NY) won Robot Skills 2nd place and 3rd place respectively, placing them all high in the national rankings.

Award	Team #	Team Name	Affiliation	Location
Robot Skills Champion (VRC/VEXU)	44777U	DiscoBotZ	DiscoBotZ Robotics	Redmond, Washington, United States
Robot Skills 2nd Place (VRC/VEXU)	16099B	Overclock	KG Computech	Flushing, New York, United States
Robot Skills 3rd Place (VRC/VEXU)	16699Y	Overclock MS	NY Youth Tech	Flushing, New York, United States

Award	Team #	Team Name	Affiliation	Location
Excellence Award - High School (VRC/VEXU)	97871A	Roverines Robotics	NEWFIELD HIGH SCHOOL	Selden, New York, United States
Excellence Award - Middle School (VRC/VEXU)	16699Z	Overclock MS	NY Youth Tech	Flushing, New York, United States
Tournament Champions (VRC/VEXU)	97871A	Roverines Robotics	NEWFIELD HIGH SCHOOL	Selden, New York, United States
Tournament Champions (VRC/VEXU)	38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States
Tournament Finalists (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Tournament Finalists (VRC/VEXU)	16099B	Overclock	KG Computech	Flushing, New York, United States
Tournament Semifinalists (VRC/VEXU)	16699Y	Overclock MS	NY Youth Tech	Flushing, New York, United States
Tournament Semifinalists (VRC/VEXU)	15239A	RoboBaller		Somers, New York, United States
Tournament Semifinalists (VRC/VEXU)	9932C	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
Tournament Semifinalists (VRC/VEXU)	11791X	Arsenal	New Energy Education Center	Syosset, New York, United States
Robot Skills Champion (VRC/VEXU)	16099A	Overclock	KG Computech	Flushing, New York, United States
Amaze Award (VRC/VEXU)	16099C	Overclock	KG Computech	Flushing, New York, United States
Build Award (VRC/VEXU)	98456B	Robo Frogs	St. Mary's Episcopal Church	Carle Place, New York, United States
Create Award (VRC/VEXU)	24642T	The Prodigies		Farmingdale, New York, United States
Design Award (VRC/VEXU)	9932X	Hawks	JERICHO SENIOR HIGH SCHOOL	Jericho, New York, United States
Energy Award (VRC/VEXU)	699E	Atomic Endgame	Thomas A Edison Career And Technical High School	JAMAICA, New York, United States
Innovate Award (VRC/VEXU/VIQC)	97140A	Kennedy Gaels	Kennedy Catholic High School	Somers, New York, United States
Judges Award (VRC/VEXU)	47114A	VEXcellent Girls	North Shore Coding and Robotics Club	Great Neck, New York, United States
Sportsmanship (VRC/VEXU)	11442X	Hewitt Robotics	The Hewitt School	New York, New York, United States
Think Award (VRC/VEXU)	38211A	Centereach Cougears	CENTEREACH HIGH SCHOOL	Centereach , New York, United States

West Virginia VEX U Robotics Qualifier Remote Skills-Only Competition, February 20th 2021

On Saturday, February 20th 2021, Vaughn College's Robotics team participated at the Fairmount State University VEX U Robotics Remote Skills-Only Tournament. The team was composed of five members (Timothy Tullio, Maharshi Patel, Kevin Tsang, Tatiana Jaimes, Misael Marquez and John Sutera).

A total of twelve colleges and universities participated in the event. The participant teams included Purdue University (BLRS), Vaughn College of Aeronautics and Technology (VCAT), New Jersey Institute of Technology (NJIT), UNL Vex U Robotics Club (UNLVU1), Bison Robotics (BISON1), University of Waterloo (UWAT), West Virginia University (WVUR1), University of Florida (GATR2), University of Calgary (ABS), The University of Central Arkansas (UCA1), Embry-Riddle Aeronautical University (ERAUB and ERAUG)

Each participating team had a total of six robot skills attempts, three driver skills, and three programming autonomous skills. Vaughn team's (VCAT) highest score for driver skills was 124 (two points from perfect), and 81 for programing skills. With a total of 205 skills points **Vaughn's team finished second place** behind the University of Waterloo with a 126 driver skills and 125 programing skills. Behind both teams was the University of Calgary with a 126 driver skills and 70 programing skills

Vaughn College (VCAT) at the 2021 West Virginia VEX U Competition

University of Waterloo (UWAT) at the 2021 West Virginia VEX U Competition

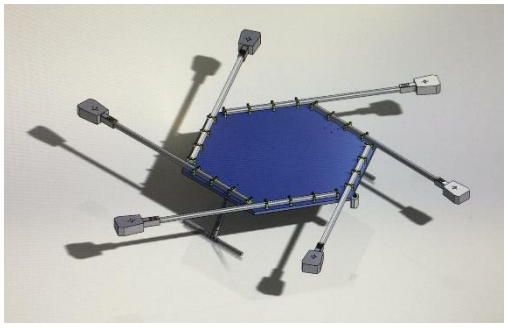
University of Calgary (ABS) at the 2021 West Virginia VEX U Competition

In this event, teams were judged and awards were granted to teams showing the most optimal traits of an effective robotics team. Vaughn's team was awarded the most prestigious award presented at a Vex Robotic Competition the **"Excellence Award"** for their tremendous attention to the engineering design process and what that design process produced. With Excellence Award, **VCAT team is qualified to participate in the 2021 VEX U world championship.**

Vaughn College UAV Club 2020-2021 Activities Report

The Unmanned Aerial Vehicles (UAV) team at Vaughn College had a rough but successful year during which the club participated in 2 virtual competitions, with 3 different teams, working towards different competition requirements. The UAV Club came in 2nd place at the national VFS MAV Autonomous and Manual categories competing against Penn State, University of Maryland, and Drexel University. The UAV club came in 26th Place out of 75 teams at the Student Unmanned Aerial Systems (SUAS) competition, hosted by the Association for Unmanned Vehicle Systems International (AUVSI), which was a major milestone for the club as a rookie team. The UAV club now strives to build upon these achievements to continue as a top performing team at these competitions, as well as to maintain its community service impact.

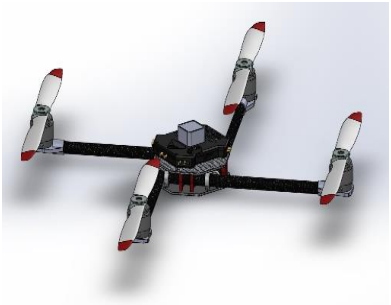
AUVSI SUAS



Custom Heavy Lift Drone Design

For the third year at the AUVSI SUAS competition, the UAV Vaughn team has begun the meticulous process of designing a system from the ground up to perform in the top percentile at the competition. The team was equipped with the latest manufacturing machines provided by Vaughn College. The college has chosen to design, build, and manufacture the UAS completely inhouse. The 2021 AUVSI SUAS competition has requirements to build an autonomous UAS with the capability to execute long range missions while being equipped with high resolution cameras to perform image detection on the ground. Additionally, the UAS must be able to carry payloads to a position given to us by the competition prior to the event. The AUVSI SUAS competition this year serves as a basis for leading-edge technology in the autonomous package delivery industry that is growing each year.

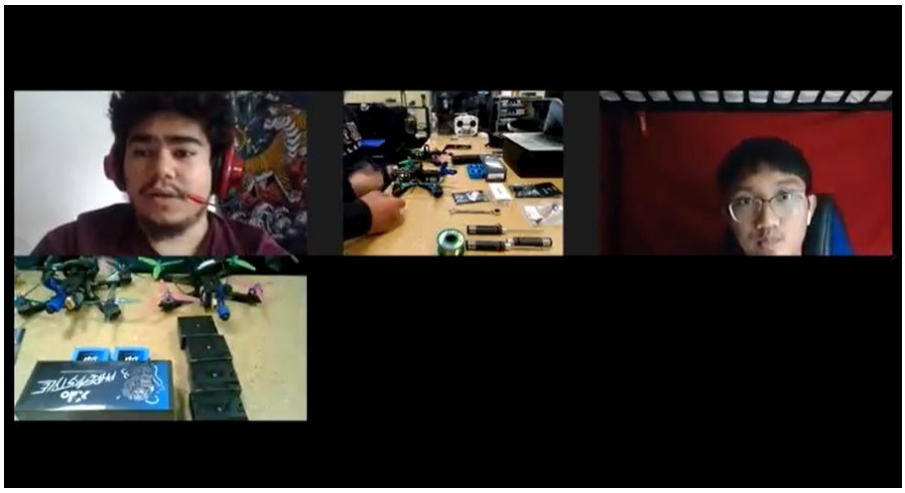
VFS MAV



The UAV Club also has teams working on indoor navigation of drones as part of the Design-Build Vertical Flight student competition hosted by the Vertical Flight Society (VFS) at the 77th Annual Forum in Grace Quarters Baltimore, Maryland. The outdoor navigational challenge is to deliver as much sand inside

a SoftGrip weight as possible, using either Manually operated or Autonomous drones in a limited amount of time. The UAV Club has chosen to participate in both the Manual and Autonomous Category. Both teams have worked diligently to satisfy the Gate 1 proposal designs, as well as the feasibility studies on both drones. Currently Vaughn's UAV team was selected by VFS as one of the finalists along with Penn State, Ohio State, Oregon State, University of Michigan, and University of Maryland to participate in the Design-Build-Vertical Flight Competition (April 16, 2021) in Graces Quarters Army Test Site, Maryland.

Outreach



Throughout the year UAV Club hosts various workshops and events to educate about small unmanned aerial systems (sUAS). Due to Covid-19, many of our workshops and events had to be held through zoom. The UAV Club hosted a Build a drone workshop, which taught students the intricate process of soldering components, as well as techniques such as wire management, part selection, and build verifications. Students also had the opportunity to build with some of the advanced components such as Pixhawk Cube flight controller and single board computers that the club uses for its autonomous flight testing.

The UAV Club has also partnered with the Vaughn College CSTEP and STEP Programs to host a drone workshop at Vaughn College. STEP is a New York State funded program dedicated to preparing historically underrepresented or economically disadvantaged secondary school students for entry into postsecondary degree. Through this workshop, the UAV Club and CSTEP strive to impact its community and to spark the interest of the young generation of students.

The UAV Club will host its signature event, Vaughn Drone Day in May again this year. Vaughn Drone Day is an annual event held at Vaughn College, where everyone is invited to attend free of charge. At this event, the UAV Club has various workshops for participants to attend, and the

hanger is set up with a net within which people can fly drones. Drone enthusiasts and professionals show off their drones and equipment at their booths and a discussion panel is held regarding drone rules and regulations. Every year people come from all over the 5 boroughs to take advantage of this event. Due to Covid-19 the Vaughn drone day will be virtual this year to follow CDC guidelines.

Vaughn's NASA Rover Club: Blasting Off to Victory

Figure 1: Example of 2019 NASA Rover

Vaughn's NASA Rover Club is a new organization focused on designing and assembling a rover that can win the NASA Human Exploration Rover Challenge. The challenge began after the crew of Apollo 14 completed their expedition to the moon. During the mission, two astronauts had to travel great distances across the moon's surface to collect materials for study. One of the astronauts, Alan Shepard, had his heart rate reach 150 beats per minute because of the physical exertion required to complete the task. Both Shepard and his partner, Edgar Mitchell, would sweat in their suits and frequently needed breaks to catch their breath. In addition, they pushed resources and time constraints to the limit with their large intake of oxygen and their lack of speed and mobility.

In response to these issues, the Great Moonbuggy Race was established, which evolved into the NASA Rover Challenge. The criteria of the current challenge are to traverse half a mile of land, and complete objectives with the use of custom-made tools. A variety of terrains must be traversed to simulate an exoplanetary landscape. These terrains include an ancient stream bed with pebbles, a simulated field of asteroid debris, erosion ruts, and crevices of various dimensions. The objectives of the challenge are to deploy a solar power cell, to perform a core sample extraction, to take four photographs, and to collect 3 soil samples and 3 separate liquid samples.

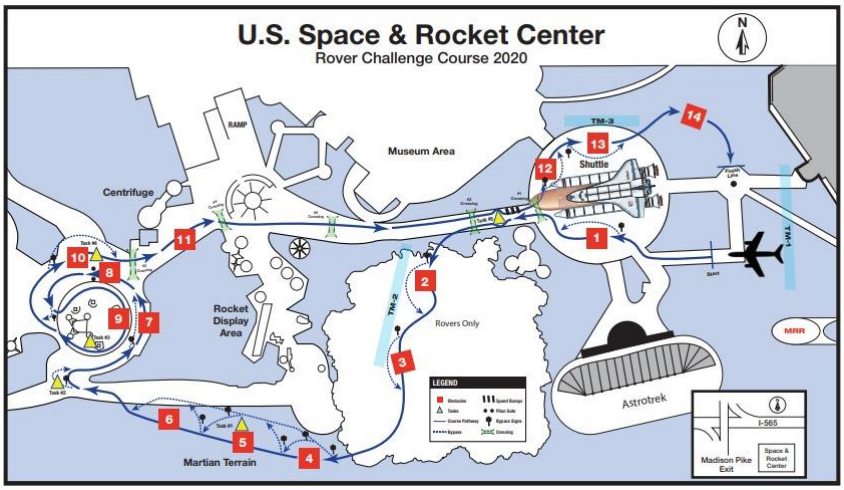


Figure 2: 2020 Rover Challenge Course

The Rover Club E-Board is comprised of 5 freshmen students, President Alina Santander, Vice President Michael Boller, Secretary Tatiana Machare, Treasurer Kevin Velasquez and Event coordinator/Social media manager Kacper Olchanowski. President Alina Santander has invaluable experience leading a NASA Rover Team to 1st place victories in multiple competitions.

Figure 3 Founding members of Vaughn's NASA Rover Club

The members interested in participating in the club's management all have an equal opportunity to do so. Elections are to be held once a year, and every member may vote for the person whom they believe will best fulfill the duties of each position.

Candidates and members with experience in mechanical engineering, mechanical engineering technology, mechatronic engineering, or any type of trade are especially beneficial to the cause. Although it is preferred that members be proficient in these skills, it is not required. Fellow members will always assist each other with completing tasks and improving skills. Teamwork plays the most important role in every organization's success: therefore, we seek students who are willing to help as well as to learn. Creativity from all members is highly encouraged, and every idea is taken into consideration.

To construct a rover for the NASA Rover Challenge, participants must understand the rules and goals of the competition. Deciding which prize the team will set as a goal is important, for the design of the rover must be devised with this choice in mind. Generally, in order to best meet the requirements for the rover, materials must be chosen that are cost effective, strong, durable, and lightweight. All rules, obstacles, and tasks pertaining to the competition are in the Guidebook on the NASA Rover Challenge website.

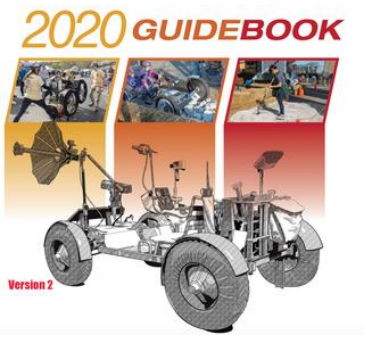


Figure 4: 2020 Rover GuideBook

Skills students acquire during this endeavor are applicable to a variety of STEM fields, including but not limited to, computer programming, mechanical and mechatronics engineering, ATI, and data science. Most of these areas of expertise are often covered in classes at Vaughn College of Aeronautics and Technology. Participation in the NASA Rover club allows students to apply class knowledge in hands on activities, leading them to acquire a deeper understanding of their various subjects. The skills the students develop are:

- 3D modeling, using SolidWorks to create tools, parts and a final Computer-Aided-Design of the rover
- 3D printing the modeled parts and tools
- Experience working with welding materials
- Experience working with machining parts
- Use of basic tools and power tools
- Collaboration and efficient use of time

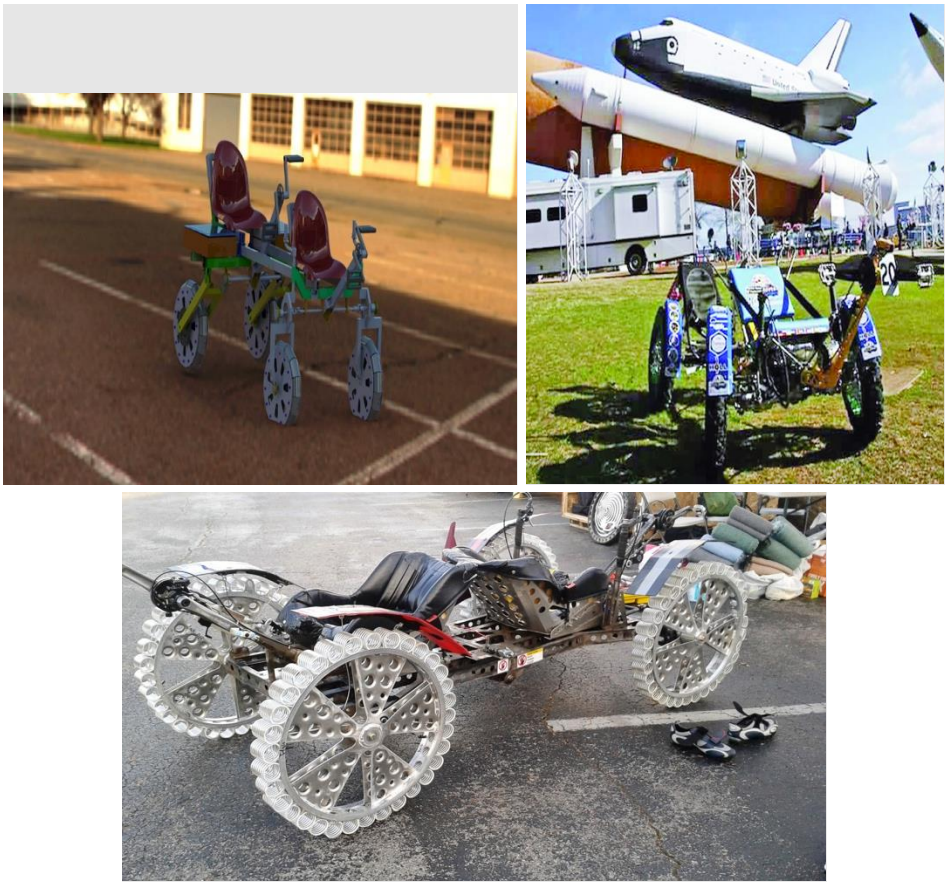


Figure 5 Rovers with design features

All of these skills are relevant in the work force, and contribute to members becoming avid candidates for internships and careers. In addition, skills practiced here can be applied back in the classroom, in the form of labs, classes, or degree projects; these experiences increase any student's chances of making it into their desired field.

2020-2021 Society of Women Engineers (SWE) Activities

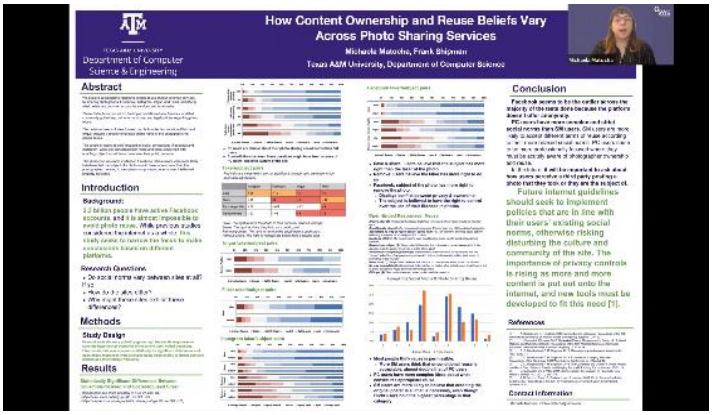
The Vaughn College of Aeronautics and Technology (VCAT) Chapter of the Society of Women Engineers (SWE) is an organization supporting and empowering female students specializing in engineering. The Chapter's goal is to highlight the importance of diversity and strengthen its legacy in a very competitive field. Not only does the Chapter groom its members to excel as engineers, but it also helps them to become well-prepared professionals who will be highly productive in their chosen field of endeavor. Furthermore, the Chapter prides itself on its STEM Outreach work to increase future female involvement and current student interest in engineering.

Women Engineering Virtual Conference 2020

The Vaughn College chapter of the Society of Women Engineers (SWE) attended the 2020 Women Engineers Conference virtually from November 2nd through November 13th, 2020. During the conference, nine members of the chapter had the opportunity to attend leadership seminars and technology talks. In addition to attending seminars, SWE students attended the career fair. Sophomore and junior members had the opportunity to interview with industry leading companies such as Johnson & Johnson, Medtronic, Blue Origin, Northrop Grumman, and Jacobs Engineering Group Inc.

Seminars

SWE-VCAT members, attended several career readiness seminars at the virtual conference; these were some of them:



SWE-VCAT vice president, Maharshi Patel, attended several seminars to biomedical engineering. This talk sheds a light on the effects of traumatic brain injuries at the cellular level.

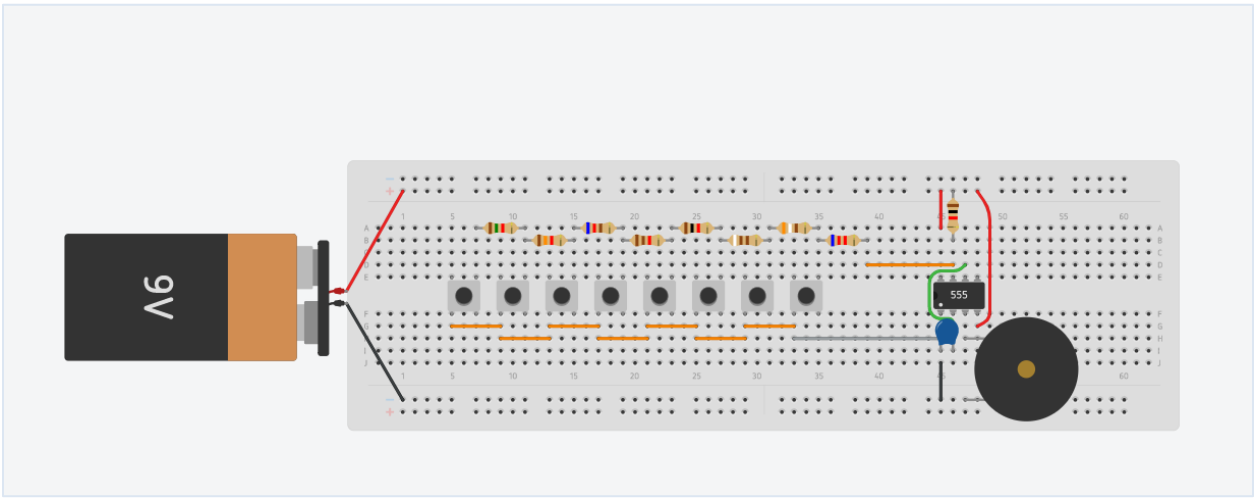
SWE-VCAT president, Alina Santander and Secretary, Tatiana Jaimes, attended the Undergraduate Student Poster Competition. This session highlights ten student poster presentations.

Some members attended a seminar that highlighted the proper uses of social media and appropriate uses of imaging to boost one's career.

SWE STEM Outreach

On December 4th, SWE-VCAT members, along with three other student organizations, were in charge of the virtual coding workshop. A robotics member, Misael Marquez, explained the basics to start programming in C ++. The workshop was carried out through Zoom and recorded for those who could not attend.

This workshop's objective was to transmit the importance of programming to the members of the four organizations involved, since this skill is necessary for projects and for daily activities within clubs and engineering classes.



On March 10th Mariah Villalon, SWE-VCAT Treasurer, hosted a workshop for middle school students. For this workshop, she had them learn how to build a simple piano circuit. She explained the circuit step by step, describing the purpose of each component. To make this workshop more interactive since it is virtual, she used a website called Tinkercad, which is a free, easy-to-use app for 3D design, electronics, and coding. SWE held this workshop to teach the students how to use resistors, pushbuttons, 555 timer, capacitor, Alert buzzer, and to set up the components on a breadboard. The picture above shows the simple piano built during the workshop. After the students had finished building the circuit, they were able to program it.

At the end of the workshop, Alina Santander gave a presentation about SWE, its activities, and its purposes to motivate children to choose a STEM career, so that they can become active in clubs in their future colleges.

Student research

SWE-VCAT members know the importance of taking up projects and writing papers. That is why several members of the club decided to present projects this year. Among them, Tatiana Jaimes, Alina Santander, and August Rodriguez worked on a low-cost teaching tool that encourages pre-K through first-grade children to learn the Braille alphabet and acquire letter recognition skills through interactive methods that stimulate their tactile and auditory senses. The paper was submitted to LACCEI, and the team is currently waiting for a confirmation.

Future Workshops

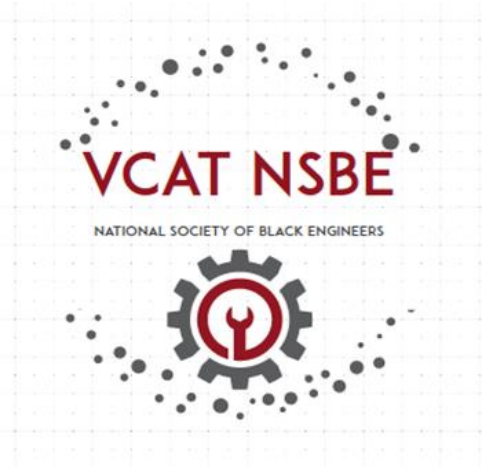
The club plans to host a minimum of two more workshops this semester:

Writing and publishing papers
SWE-VCAT wants to convey the importance of writing papers and how this can benefit students' careers for their future. This workshop will be led by Professor Donald Jimmo, who also advises several students on paper writing.

Alumni session
SWE-VCAT plans to have a session with Vaughn College alumni who were part of SWE before graduating. The club wants to invite three engineers who now work in the industry to present the importance of being part of this chapter during their college stay. After their presentations, a question-and-answer session will be held so that their experience can help and guide current SWE-VCAT members.

2020-2021 National society of Black Engineers (NSBE) Club Activities

The National Society of Black Engineers is a worldwide organization geared towards the professional, academic, and social development of members. The goal of the national society of engineers is to "increase the number of culturally responsible black engineers who excel academically, succeed professionally, and positively impact the community." To promote these developments, our organization hosts and organizes a series of events yearly. These events include webinars, workshops, career fairs, conferences, and conventions where members can be exposed to many enrichment activities. During each of these events members are exposed to multiple industry connections and internship opportunities that will help them on their path to becoming successful engineers.



Vaughn College's chapter of The National Society for Engineers, established in February 2017, also provides development opportunities to continue in alignment with the goals of the organization. Although our organization aims for the development of black engineers, our club is open to individuals of all ethnicities who are interested in gaining valuable experiences throughout their career path. During the 2020 – 2021 year, our chapter has continued to collaborate with other regional chapters and has organized several events and activities to help our members gain necessary skills and talents they need on their path to becoming professionals. Unfortunately, due to the outbreak of the corona virus, all events were held online without in person interactions; however, with the continuous support of the college and with the extraordinary efforts of our club's leadership we were still able to conduct effective events that were not only fun but highly beneficial to our members and nonmembers alike.

Region 1 Metropolitan/ Long Island Fall Zone Conference – October 2020

In the fall of 2020, six of our chapter's members attended our organization's zone conference. At this event, our members were exposed to multiple workshops where they were taught valuable skills and knowledge needed on their path towards becoming engineers. The theme of this conference was "Climbing the Silver Stairs," and it discussed how individuals can strive and keep moving forward, despite the countless barriers in our path. One of the many remarkable and memorable events featured was the "Life After College Workshop." At this event, individuals engaged in a highly interactive discussion focusing on their future goals and plans and how to begin taking the first steps in achieving these goals.

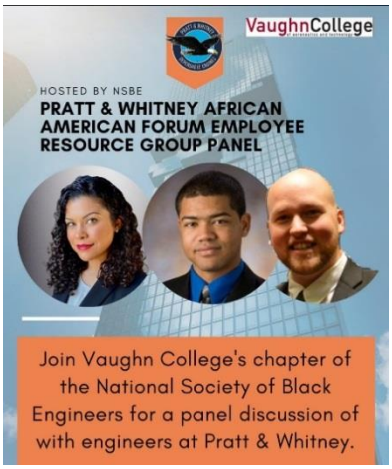
Region 1 Fall Regional Conference – November 2020

This regional conference was held in the fall, and seven of our members were able to attend and benefit from this event. The conference features a variety of workshops and industry connection events; members were also exposed to career and internship fairs where companies were actively seeking potential candidates. This conference provided an opportunity for individuals to speak with local professionals from engineering business on a one-to-one basis. The goal of the conference was to enhance and develop the potential of members to become leaders in industry and the community. The conference was centered around the idea that as successful engineers and future leaders, we need to have a balance in all aspects of our lives.

Resume Build Workshop – February 2021

This workshop was done in collaboration with career services to prepare members for the upcoming national convention. Our members were given a presentation about basic skills and strategy needed for building a strong and effective resume. At this workshop members were taught about different resume formats and the effective use of action verbs to improve their resume to make it more appealing. Attendees were also educated on what to include and not to include in a resume, so that it will stand out to any employer.

Pratt and Whitney Q&A Panel – March 2021



This workshop was done as a panel discussion where attendees were given the opportunity to have their questions about possible career and internship opportunities answered. It was an excellent opportunity to connect with professionals at Pratt and Whitney. This event featured three panelists who, as members of the National Society for Engineers, were incredibly enthusiastic about sharing their stories with fellow members. The panelists were Gabriel Lavoie who is a Junior Engineer, Stacie Dawson who is a Test Analysis Engineer, and Gregory Harrell who is an Externals Design Engineer. This event was an extraordinary opportunity for attendees to gain valuable knowledge and to learn about the future of the company.

Interview Prep Workshop – March 2021

In this workshop, career services gave an amazing and in-depth presentation about various interview practices. Attendees were informed about the interview process, as well as about the various forms of interviews. Members were taught about appropriate interview attire, as well as about what makes candidates stand out to an interviewer. It was an enlightening workshop, because attendees were informed about various interview questions, as well as how to answer them.

Elevator Pitch Workshop – March 2021

This workshop was held in preparation for our organization's national convention. This event was highly educational, as it allowed members to gain necessary skills and techniques needed when connecting with a professional. During this event attendees were shown various presentations on how to develop and project an effective elevator pitch. Members were also introduced to professional body language, in order to make a substantive impression on anyone with whom we are trying to connect.

47th National NSBE Convention – April 5th – 9th 2021

The 47th National Convention was most impressive; even though it was held online, there was nothing lacking throughout this entire event. During the five days of this convention, there were countless opportunities to connect with professionals and gain valuable knowledge every step of the way. Seven of Vaughn's NSBE chapter's members attended, along with nine non-members who shared an interest in this national conference. The theme of this convention was "The Holistic Engineer," and it featured multiple workshops, seminars and forums that were aimed towards the overall development of the attendees and focused on increasing the number of black engineers who excel and become leaders of the future. A memorable workshop was, "The Life I Want, The Career I Choose." This event featured multiple business professionals who were willing to share information about their past decisions and experiences which have led them to achieving their goals. The presenters reminded attendees that, "Hard work leads to a successful future," and they educated them on how to make the right decisions to advance them on their path to their future goals. The 4th and 5th day of the convention featured a career fair with over 200 companies nationwide in a wide variety of industries. Every attendee had the opportunity to connect with professionals from each of these companies and was exposed to many recruiters hiring for long term careers and internships.

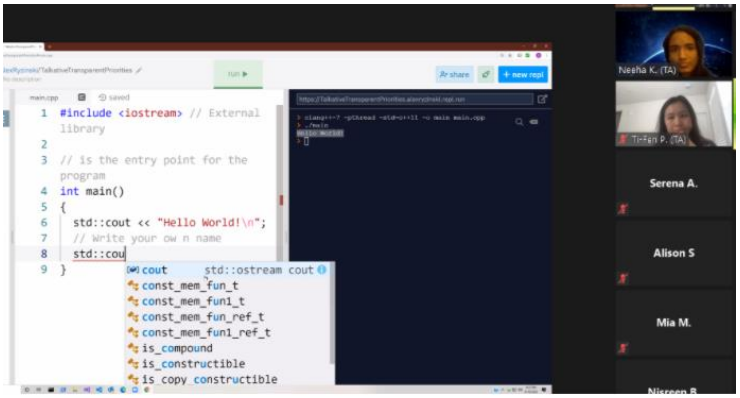
2020-2021 Society of Hispanic Professional Engineers (SHPE) Club Activities

SHPE National Convention Readiness [Sep & Oct 2020]

All participants of SHPE's largest event are expected to attend multiple activities in order to ensure the best possible results for each participant. Resume building, company research development, dressing to impress, interviewing skills, and even mock interviews are all part of these activities. Our elected E-Board had one-on-one meetings with members to fully prepare them for interviews by having a list of commonly asked questions. Resumes from former participants, as well as resumes reviewed by Vaughn College's career center, are included in the resume building seminar. All resumes should be accompanied by a strong portfolio consisting of projects completed on one's own time as well as any projects completed during the academic years. Our SHPE alumni and members with experience volunteer their time to assist members in learning what would be asked of them during an interview. This means that when our members are offered an interview spot with one of the businesses, they will be prepared to answer every question.

SHPE National Convention [Nov 2020]

The SHPE National Convention is the largest professional and Career Conference held by the SHPE organization. This event will assist SHPE participants in gaining professional experience. This conference also provides members with the opportunity of an interview, which will get them one step closer to an internship or a full-time opportunity with an engineering-centered company. The SHPE Conference is an excellent place to network and advance one's career. SHPE assists participants in developing a wide range of soft skills and leadership abilities. The Vaughn College SHPE chapter is very helpful for future students attending the University by providing them with professional skills, networking opportunities, and hands-on experience needed to enter the real world.



SHPE Coding Workshop [Dec 2020]

The Society of Hispanic Professional Engineers (SHPE) hosted a coding workshop where coding basics, syntax, conditional 'if' statements, and 'while' loops were taught by one of our Executive Board members, who is also one of the main competition programmers from our VCAT Robotics Team. This workshop was a great opportunity for those students who seek to develop programming skills or to further their programming knowledge. Also, a second workshop was hosted two weeks after for those who sought to improve the skills they previously acquired in the first workshop. In the second session, members were taught how to write a simple code to make one of our competition robots move and pick up an object.

SHPE Virtual Game Night [Feb & Mar 2021]

The Society of Hispanic Professional Engineers (SHPE) hosted their first-ever Virtual Game Night providing students and members the opportunity to engage with one another safely from their computers. This event is hosted by the chapter once a month, to help students to de-stress from classes and examinations through Hispanic influenced games like LOTERIA and OUTBURST. The Vaughn College administration aids our chapter in this event by providing the funds to cover the prices mentioned on the flyers shown.

HSI-STEM Grant Activities

Through "Developing Guided Articulated Completion Pathways in Leading Edge Aeronautics and Aviation Careers for Hispanic and Low-Income Students," Vaughn College continues to develop a much needed pathway for Hispanic students to increase accessibility to the College's engineering degree programs. Project goals include:

1. Close academic achievement gaps where students are at high risk of failure or withdrawal, including increasing the percent of Hispanic and low-income students who participate in grant-supported services or programs and who successfully complete gateway courses, and increase the percentage of Hispanic and low-income students who participate in grant-supported services or programs and who are in good academic standing
2. Expand focus on persistence to include the development or redesign of instructional programs and support strategies that facilitate Hispanic and low-income student transition through upper division studies in high demand STEM fields.
3. Strengthen college capacity for offering opportunity equity for all students, through stronger outreach to high school and community college students.

Progress Summary: We are very pleased with the significant progress made toward meeting overall goals and objectives, including steady increases in enrollment in STEM related programs. The Engineering and Technology department is making significant progress toward implementation of those goals. Below are current initiatives the College is implementing to attain those goals:

- Supplemental Instruction (SI) and Mentoring group is a student academic assistance program that increases academic performance and retention through the use of collaborative learning strategies. The SI program at Vaughn targets challenging mathematics, engineering, and physics courses and provides regularly scheduled, out-of-class, peer-facilitated sessions that give students the opportunity to process the information learned in class. Supplemental instruction is a proactive approach to student learning and engagement which increases student persistence and retention.

  Under the college's current Title III grant, Vaughn assigned ten to fifteen SIs in fall 2019 and spring 2020 to assist and improve students' performance through fundamental engineering and engineering technology related courses. Also, Vaughn's two writing specialists in the Teaching and Learning Center (TLC) assisted many students with their capstone degree projects, technical writing and presentation. As a result of this program, some of our students' research projects were accepted for publication and presentation in technical conferences such as the YPSE AIAA Mid-Atlantic Section conference, COMSOL Multiphysics conference, annual conference of the Society of Women Engineers, Southern Biomedical Engineering Conference, Latin American and Caribbean Consortium of Engineering Institutions, and Society of Hispanic Professional Engineers (SHPE) (**attaining goals 1 & 2**).

- The College's current Title III grant (P031C160021) provided additional funding support to further expand student involvement in STEM related scholarly and practical hands-on activities. This includes student engagement in paper and poster session competitions of

technical conferences (LACCEI, AIAA, SWE, and SHPE) as well as their involvement in robotics, UAV, and NASA Rover club activities and competitions. As a result of this program, Vaughn's engineering students participated and presented their research papers in the 2020 LACCEI International Conference and received the First place award for the student paper session competition, as well as the First place award for the student poster session competition of this international virtual conference. Two of Vaughn's engineering students participated and presented in the 36th Southern Biomedical Engineering Conference, and they received 3rd best presenters award for this regional conference. Vaughn's Robotics club finished second in the VEX U International Mexican Robotics competition. Vaughn's SHPE student chapter participated in the 2020 Society of Hispanic Professional Engineers (SHPE) Virtual Conference, and the Vaughn College chapter of the Society of Women Engineers attended the 2019 Women Engineers (SWE) Virtual Conference (**attaining goals 1 & 2**).

- For the academic year 2019-2020, students in Vaughn's technical clubs (Robotics, UAV, and NASA Rover) and Vaughn's student chapter of professional societies (SWE, EWB, NSBE, and SHPE) organized and hosted several STEM related workshops for middle school and high school students during Vaughn's Annual Manufacturing Day, and Vaughn's Annual STEM Day. They also provided assistance to many high schools to host their regional robotics and drone competitions. Vaughn's UAV team continually assists the Cradle of Aviation Museum in developing and hosting drone games and competitions for high school students. The PD along with faculty attended some of these events to increase awareness about Vaughn's engineering programs (**attaining goal 3-outreach**).

- **Program Articulations:**

  - On Thursday October 31, the PD signed a program articulation with Hillcrest High School. As part of this articulation, Hillcrest Junior and Senior level students may enroll for MCE101 (Introduction to Robotics, 1 credit, 3 contact hours), CDE117 (Engineering Graphics, 2 Credits, 4 contact hours), CSC316 (C++ Programming, 3 credits) at Vaughn College, and upon successful completion with a grade of C or better, these courses can be applied towards a Vaughn College engineering and engineering technology degree.
  - In November 2019, the PD with the Assistant of the Associate Vice President of Academic Affairs established a 4+2 agreement with Freeport high school for both AAS Aeronautical Engineering Technology and AAS Electronics Engineering Technology-Avionics. The goal is that summers would be intense academic interventions on the Vaughn campus for the Freeport HS students. Fall and spring would likely be on the Freeport high school campus with either hiring, training and certifying Freeport teachers as Vaughn adjunct faculty or sending our faculty to the Freeport campus. We are ensuring the lab courses (which take special equipment) are taught at Vaughn and courses that don't need equipment beyond what is at a high school can be taught there.

- **Advanced Manufacturing Training and Workshops:**
  1. **STEM Pathway Workshop:** On Friday March 6, 2020, the PD with the grant team and STEM pathway liaison organized and hosted its second STEM Day workshop for community colleges. The participants of Vaughn's STEM Day workshop were students and faculty from Passaic, Bergen, and Queensborough Community Colleges. In the morning session, Vaughn's STEM Pathway Liaison and STEM project director talked about Vaughn College's program offerings in engineering and engineering technology disciplines as well as student involvement in various STEM related clubs and professional activities. From 10:30 am to 11:30 pm, Avionics program coordinator, Prof. Mudassar Minhas, introduced audiences to the aircraft avionics system related to radar, navigation and communication. From 11:30 pm to 12:30 pm, Prof. Manuel Jesus, CNC and Additive manufacturing Curriculum developer, hosted a workshop at Vaughn's 3D Maker Space Center on 3D additive and subtractive manufacturing process using various 3D priming machines. In the afternoon session, from 1:00 pm to 2:00 pm, Vaughn's UAV and SWE clubs engaged participants in hands-on STEM workshops sessions on design and building a drone for UAV competitions (VFS Micro Air Vehicle Student Challenge and AUVSI-SUAS). Finally, from 2:00 pm to 3:00 pm, Vaughn's CNC lab specialist, Mr. Rachid Nafa, introduced participants to a hands-on session on part design and manufacturing process using the HASS VF-2SS CNC milling machine, the Okuma lathe machine, and the Coordinate Measuring Machine (CMM).
  2. **12th Annual Technology Day Virtual Conference:** On Friday May 29, 2020, the Engineering and Technology department hosted its Twelfth Annual Industry Advisory Meeting and Technology Day Virtual Conference. Dr. Rahemi, updated Advisory Council members on recent developments in the Engineering and Technology Department, such as preparation for the initial 2020 EAC ABET accreditation of ME and EE programs, HSI-STEM grant activities including development process of stackable manufacturing certificate programs in CNC machining, Composite, and 3D additive and subtractive manufacturing that lead to a BS in advanced manufacturing program, establishment of manufacturing laboratories (CNC machining, composite, additive manufacturing, and PLC & automation), and plans for the development of the UAS laboratory and certificate program. The PD updated advisory members on grant supported STEM activities as well as student engagement and outreach activities. Each technical club provided their annual club activities and accomplishments to the audience at the Virtual Tech day Conference, and finally, capstone degree presenters talked about their innovative research project. The top 3 research papers were selected by our Industry Advisory members as the recipients of the Best Student Paper awards of this session. In conclusion, Dr. Rahemi congratulated all capstone paper and technical club presenters and emphasized how impressive the presenters' accomplishments have been and how proud the Vaughn community is for all of their hard work.
  3. **6th Annual Manufacturing Day Virtual Conference:** The Department hosted the 6th annual Manufacturing Day conference on Friday October 30. 2020 1 (10 am to 1 pm) to celebrate national Manufacturing Day. The guest speakers addressed the Vaughn community, faculty, and invited guests about current manufacturing innovation in the area of AM Journey to Production, Drone Manufacturing and ISO Manufacturing

Standards, Digital Manufacturing and the IIOT: Success with a Single Platform, Industry 4.0-Part II, and additive manufacturing with consumer grade low cost 3D printers.

4. **6th Annual Manufacturing Day Virtual STEM Workshops:** On Friday October 30. 2020, In a parallel session, from 10 am to1 2:00 pm, Vaughn's Robotics, SWE, and UAV clubs organized and hosted virtual STEM workshops for the high school students. These workshops covered Robotics and UAV design & autonomous programing, as well as team preparation for the 2020-2021 VEX U Robotics and VFS-MAV competitions

These hands-on workshops and training courses helped the grant management team with valuable lessons in the development process of facilities and laboratory equipment that will allow Vaughn to provide our students with practical hands-on STEM manufacturing training that is current with today's industry demands.

- **Stackable Certificate Programs:** In fall 2020, the grant management team was able to complete and submit the UAS certificate program to NYSED for their review and approval.
  - ✓ **UAS Certificate Programs:** In early September, the PD with the assistant grant manager submitted the UAS certificate program to the New York State Education Department (NYSED) for their review, and in January 2021 this certificate program received NYSED approval. This certificate program has 5 courses and 13 credits. The following courses are part of this certificate program.
    - UAS200 – Introduction to Unman Aerial Vehicles (Design, Operation, and system architecture for UAS), 3 Credits
    - UAS220 - **Drone Laws and Remote Pilot Certification,** 3 Credits
    - UAS231 - Introduction to Drone Aerodynamics, 3 credits (2 credits lecture & 1 credit Lab)
    - UAS241 - Drone Application – Lan Surveying , 2 Credits (1 credit Lecture & 1 credit lab)
    - UAS251 - Drones Rapid Prototyping and System Integration, 2 Credits (1 credit lecture & 1 credit lab)

In addition, during the academic years 2017-2018 and 2018-2019, the grant management team and the PD completed two certificate programs in **1) 3D Additive & Subtractive Manufacturing 2) Composite Design & Manufacturing.** 3**) CNC Machining and Manufacturing,** and all certificates received approval from the NY State Department of Education.

- **Laboratory Development:** With the support of the HSI-STEM grant, the Engineering and Technology Department established two new state-of-the-art facilities: the Composite Manufacturing Center and the CNC Machining Center, and is currently establishing a UAS Center. During the academic year 2020-2021, HSI-STEM grant funding support allowed the department to make enhancements to its currently

established 3D Makerspace Center and CNC machining centers. In the 2020 academic year, the department completed the purchase of the following laboratory equipment:

1. Equipment for UAS lab (Dual Quadrotor for indoor unmanned aerial vehicle (UAV) research, Quanser Aero USB, and other equipment and accessories to design and construct a drone), price $77,000. Lab tech is completing the installation of UAS lab and this lab will be used to provide students with hands-on skills in courses within both the UAS certificate program and the BS in Advanced Manufacturing program.
2. Plasma table for CNC metal cutting with accessories, cost, $2,590.75
3. Peopoly Phenom L MSLA 3D printer for mass production of high-precision for students and technical clubs projects, cost $2,909.03
4. 3D USA Precision 350 extruder, filament, nozzle pack, puller wheel and accessories for 3D Makerspace center, cost $14,157.80
5. SV2 printable circuit board (PCB) printer for 3D Makerspace center to support implementation of stackable manufacturing certificates and BS in advanced manufacturing program, cost $20,146.00

This laboratory equipment allows Vaughn to provide students with practical STEM hands-on training in CNC, Composite, UAS, and 3D additive and subtractive manufacturing, on equipment current with today's manufacturing industry standards.

- **Students' accomplishments and success:** Below is a list of student accomplishments and successes that are a direct result of the current HSI STEM grant and its implementation process:

1. The Vaughn College robotics team participated in numerous local, state, and world championships events winning or placing high in all of them. Vaughn's robotics team has been a great outreach tool, as well as a great intervention to increase engineering student retention and success.
    - From December 12-14, 2019, the Vaughn College Robotics team, one of the top competitors in the 2019 VEX U Robotics World championship, was invited to participate in Mexico's VEX U International Reeduca Robotics competition in Cancun, Mexico. The team finished second place overall in the competition and won the Build Award of this international robotics competition. For the past five years, Vaughn robotics team members consistently demonstrate persistence and drive in order to attain their title as champions (2015, 2016, and 2017) and top competitor of Mexico's VEX U Robotics competition (2nd place in 2018 and 2019).
    - On Friday Feb 28, 2020, the department chair along with the Vaughn College Robotics team hosted its Sixth Annual VEX U College Regional Robotics Tournament. A total of thirteen teams participated in this regional robotics competition. Vaughn's Robotics Team wins 2020 VEX U Skill Challenge and Excellence Award and a qualification to participate in 2020 World VEX U Robotics Championship.

- On Saturday March 6 2020, Vaughn College's Robotics team participated at the West Virginia VEX U Robotics Regional Tournament. Vaughn's robotics team finished first during qualifying matches and finished 2nd place in "Robot Skills"

- **Robotics Outreach Activities:**
  - ✓ On January 25th, 2020, Vaughn's Robotics Club assisted John F. Kennedy High School to host its first high school robotics competition on Saturday January 25th, 2020. A total of 34 regional high schools attended the January VEX state qualifier. Five members of the Vaughn's robotics team acted as referees, judges, and event manager for this regional competition.
  - ✓ On Saturday February 1st, 2020, Freeport High School hosted its regional state qualifier robotics completion, and more than thirty five regional high schools participated in this competition. Nine members of Vaughn's robotics team, along with a couple of faculty members, participated in assisting Freeport High School with this regional tournament. Vaughn's faculty and students served as judges, referees, and announcers for this regional high school robotics competition

  - ✓ The PD, Faculty, and Vaughn Robotics team assisted Vaughn College in hosting its sixth annual state qualifier high school robotics competition on Saturday February 29, 2020. A total of 58 regional high schools from Queens, Brooklyn, Bronx, Nassau, and Suffolk and other NY counties attended the February VEX state qualifier at Vaughn College.
  - ✓ Vaughn's Robotics team hosted a robotics workshop for community college students during Vaughn's Annual STEM Day Workshop on Friday March 6, 2020.
  - ✓ On January 25th, 2020, Vaughn's Robotics Club assisted John F. Kennedy High School in hosting its first high school robotics competition on Saturday January 25th, 2020. A total of 34 regional high schools attended the January VEX state qualifier. Five members of Vaughn's robotics team acted as referees, judges, and event manager for this regional competition.

2. Since 2016, the Vaughn College UAV team participated in the Micro Air Vehicle completion of the Vertical Flight Society (VFS) Conference and won top place in the MAV student challenge completion.
   - Vaughn's UAV team project was selected as one of the finalists along with Penn State, Drexel University, and University of Maryland to participate in the 7th annual Micro Air Vehicle (MAV) student challenge competition at the University of Pennsylvania on Monday May 13, 2019. On Tuesday May 14, Judges from aerospace industries evaluated team performances, and

Vaughn's UAV teams received 2nd place awards for both remote control and autonomous categories with a total $1750 check.

- From June 11-15, Vaughn's UAV team participated at the 2019 AUVSI UAS Competition alongside seventy five other top-recognized national and international engineering schools (Harvard, Cornell, Virginia Tech, UCLA, Penn state, University of Maryland, and many others) and received 26th ranking of the 2019 AUVSI challenging competition.
- **UAV Outreach Activities:**
  - ✓ Since 2016, Vaughn's UAV team assisted the **Cradle of Aviation** Museum with UAV workshops and competitions for middle school and high school students. On Saturday February 1st 2020, Vaughn's UAV team organized and hosted its 2nd Tiny Whoop Race, in partnership with the Cradle of Aviation Museum for middle school and high school students.
  - ✓ Since 2015, Vaughn's UAV team hosted several STEM workshops for High School students on learning how to build a drone, along with a drone flying session in Vaughn's hangar during **Vaughn's Annual Manufacturing Day conference**.
  - ✓ Since 2016, Vaughn's UAV team organized a day of drone workshops related to Arduino Programming, CAD Modeling of Quadcopters, and Learn to Build a Drone to celebrate **International Drone day.**
  - ✓ Vaughn's UAV team hosted a drone workshop for community college students during Vaughn's Annual STEM Day Workshop on Friday March 6, 2020.

3. **LACCEI 2020 International Conference:** From July 27-31, the following Vaughn student research papers were selected to compete among ten finalists for the student paper session of the LACCEI 2020 virtual conference.
   - ✓ **"Modular Torque Wrench Extension with Heads-up Display"** by Atif Saeed, Juan Aguirre Rodrigues, and Juan Castano
   - ✓ **"Autonomous Medication Distributor Through Implementation of Bresenham's Line Algorithm"** by Brandon Duran, Diego Villegas, and Sebastian Valencia
   - ✓ **"Development of an Advanced Robotics Program for Middle and High School student"** by Ryan Tang Dan and Maharshi Patel.

   Vaughn's student team paper presentation by Atif Saeed, Juan Aguirre Rodrigues, and Juan Castano that covered the design, development, and manufacturing process of **Modular Torque Wrench Extension with Heads-up Display** was selected by judges as a **first place award recipients of 2020 LACEEI student paper session competition** Also, Vaughn's student poster by Brandon Duran, Diego Villegas, and Sebastian Valencia outlined their degree capstone project **"Autonomous Medication Distributor through Implementation of Bresenham's Line Algorithm"** was

selected by judges as a **first place award recipient of the 2020 LACEEI student poster session competition**

4. **2020 Southern Biomedical Engineering Conference:** From March 6-8, two Vaughn engineering students, Atif Saeed and Sebastian Valencia, along with faculty advisor, Dr. Mohammed Benalla, participated and presented their research project in the 36th Southern Biomedical Engineering Conference in New Orleans LA. The presentations took place between 6:00 PM and 7:30 PM. Atif Saeed presented "Haptic Thermal Feedback Prosthetic Brain-Controlled Arm" and won the third place award in the undergraduate category, while Sebastian Valencia presented "Autonomous Medicine Dispenser". Both papers were accepted for publication in the Biomedical Science Instrumentation Journal.

In addition to the above accomplishments, as a result of the HSI STEM grant many of Vaughn's students were enabled to participate in scholarly activities and student paper and poster sessions in regional, national and international conferences and competitions (ASEE, LACCEI, SWE, ASME, SHPE, and IEEE) and receive top ranking in those events. Also, the HSI STEM grant provided necessary funding support for clubs such as SWE, EWB, SHPE, and NSBE to be involved in professional development, activities, and STEM related workshops at Vaughn College. The Student engagement section of the VCJET journal provides more details regarding these activities and student successes and accomplishments.

Vaughn College Collegiate Science and Technology Entry Program (CSTEP) 2020-2021 Activities Report

Program Overview

The Collegiate Science and Technology Entry Program (CSTEP) is a New York State Education Department (NYSED) grant provided to institutions for the purpose of increasing the number of students from underrepresented groups who are pursuing professional licensure and careers in STEM fields.[1] CSTEP at Vaughn College is open to NYS residents enrolled full time in a Engineering, Engineering Technology or BS Aircraft Operations- Pilot License degree program.[2] CSTEP at Vaughn College began in Fall 2020.

Extended Workshop Series

Throughout the Spring 2021 semester, CSTEP and faculty from the Engineering department teamed up to develop a 5-week (3 hours per week) workshop series that reviews multiple engineering topics.

FEM- Fundamentals of Engineering Mechanics
Instructor: Dr. Ghania Benbelkacem
Teacher Assistant: Bruce Tenesaca
Dates: Fridays 9:30am-12:30pm (1/22/2021-2/19/2021)

The FEM workshop developed first and second year engineering student ability to tackle basic concepts in Engineering Mechanics such as Free Body Diagrams and Static equilibrium of rigid bodies. This problem-oriented workshop was designed to make students capable of setting the problem and formulating a path to static equilibrium solution. Students also practiced mathematical skills such as linear algebra, vector calculus, and trigonometry.

FEE-Fundamentals of Electrical Engineering
Instructor: Dr. Mohammed Benalla
Teacher Assistant: Bobir Muradov
Dates: Fridays 3:00pm-6:00pm (4/9/2021-5/7/2021)

The FEE workshop reviewed the basics of Electrical Engineering in terms of electrical and electronic circuits over a five-week workshop. In the first three weeks the students will cover DC/AC Circuits, Superposition &Thevenin Theorems along with Wheatstone bridge. For the second half of the workshops focus shifted to electronic circuits, and students became more familiar with diodes, rectifiers, filters, and regulators, along with some basics on bipolar junction transistors.

CATIA Certification Workshop
Instructor: Dr. Manuel Jesus
Teacher Assistant: Bruce Tenesaca
Dates: Fridays 9:30am-12:30pm (4/16/2021-5/14/2021)

The CATIA workshop served as a review for CATIA V5 fundamentals in preparation for the Dassault Systems CATIA V5 certification examination. Over the course of five weeks, students reviewed fundamental CATIA concepts such as sketching, sketch editing, constraints, part design features, drafting, and assembly.

CSTEP Spring 2021 Research Program

CSTEP students (of all levels-first year though senior year) had the opportunity to apply for the CSTEP Research program. There were a total of 22 students selected to participate in research. Each research group was comprised of 2-4 students, with a student selected team leader and faculty mentor. Students conducted research over the course of the Spring 2021 semester. At the end of the semester, each research group's findings were culminated in a final paper and presentation.

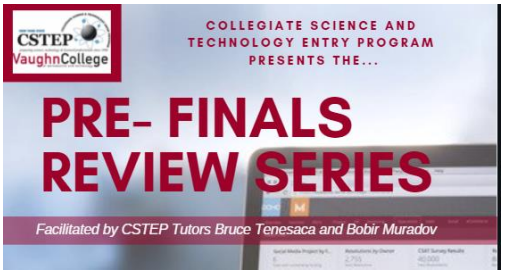
CSTEP Spring 2021 Research Program - Student Participants

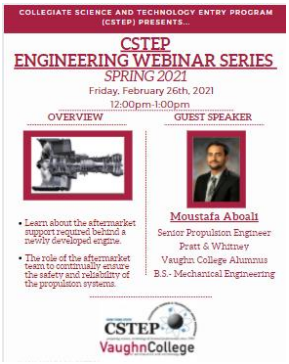
Abdullah Khan
August Rodriguez
Cesar Valle
Chavez Reece
Courtney Scott*
Daniel Garcia
Darius Palmer*
Deno Jordan*
Isa Al-Maktoum
Kastrinpaul Thevasahayam*
Kastronepaul Thevasahayam*
Mariah Villalon
Rafacely Brito*
Randy Ramos*
Rebecca Snyder
Ricardo Tomala
Samia Oishi*
Steven McAdam*
Suraiya Nawaz
Tatiana Jaimes
Tiffany Zavala*

**indicates student was a Team Leader.*

Pre-Finals Review (Spring 2021)

The Pre-Finals review series was hosted by the CSTEP tutoring staff- Bruce Tenesaca and Bobir Muradov. Each tutor was provided final exam review material from instructors from courses that CSTEP students indicated as challenging. There were a total of 10 workshops held for 5 different engineering courses.





CSTEP Engineering Webinar Series- 2/26/2021

Vaughn College Alumnus Moustafa Aboali spoke with current CSTEP students about his work as a Senior Propulsion Engineer at Pratt & Whitney. Mr. Aboali shared his story about graduating with a B.S. in Mechanical Engineering from Vaughn and outlined how hands-on experience, career milestones, a strong resume, strategic networking and decision making helped Mr. Aboali succeed professionally.

Career Development CSTEP Career Services Workshop Series (Spring 2021)

CSTEP, in collaboration with Career Services Internship and Career Advisor Sandra Buatti-Ramos, presented a series of workshops to CSTEP students that focused on career/professional preparedness in the engineering field.

Effective Resume Building- 2/5/2021

CSTEP students learned important tips and tricks for mastering the art of resume writing. CSTEP students reviewed the skills necessary for writing a technical style resume and engaged and asked questions about how to highlight their own experiences.

Identifying and Applying for Job and Internship Opportunities- 2/23/2021

A critical experience for CSTEP students is securing an internship and getting hands-on experience with an industry professional. CSTEP students gained insight into the traditional interview/job hiring cycle, and various ways to narrow down a job or interview search.

Introduction to Interviewing- 3/25/2021

CSTEP students reviewed strategies for providing strong interview question responses, types of interviews (group, one on one, screening, etc…), how to prepare for both in person/online interviews and more.

What is Engineering- 3/13/2021

Guest Presenter: Joan Cruz (CSTEP Student)
CSTEP and STEP staff members Cecelia Izzo and Cherrie Illidge, made a presentation to middle and high school STEP students about degrees and potential careers in the engineering field. The workshop also highlighted the importance of "Stacking your resume" by gaining experience in the engineering field before, during, and after college. Guest presenter Joan Cruz came and spoke about his experience as a student pursuing an engineering degree. Joan also discussed his experience working as an Engineering Project Planner at SpaceX.

Drone Day 5/1/2021

Drone Day was held in collaboration with Vaughn College's Science and Technology Entry Program (STEP), UAV Club President and CSTEP student Andrew Ramos and CSTEP Day of Service Planning Committee Members: Deno Jordan (chair), Manolo Duenas (CSTEP Student) and Tiffany Zavala (CSTEP Student). Andrew presented an informational workshop to middle and high school students that reviewed Drone Safety, the evolution of Drone technology, utilization of drones in everyday life and general techniques for flying a drone.

CSTEP CAD Robotics Workshop- Day of Service- 5/8/2021

After the interactive activity, some student from the CSTEP Spring 2021 Research Program presented their research projects to students. Presenters and topics included:

CSTEP Research Group	Research Topic
Tiffany Zavala	Developing a Collapsible Wheelchair Attachment
Deno Jordan, Samia Oishi, Kastronepaul Thevasahayam	Automatic Shopping Cart
Steven McAdam & Cesar Valle	The Use of Thermo-electric Generators to Recycle Thermal Energy Produced by Electronic

List of 2020 Placement Activity

The following table provides graduate career placement statistics within the Engineering and Technology Department for the 2020 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 by graduate schools. During the academic year 2020, our students obtained internships and accepted employment at several corporations, including Boeing, GE, NASA, Raytheon, Tesla, Daimler, Sikorsky Aircraft, Marotta Controls, Toyota, Siemens, Cummins, Northrop Grumman, Lockheed Martin, Easy Aerial, Pratt and Whiney, John Deere, Rolls-Royce, Volvo, Stryker, Magellan Aerospace, SciMax Technologies, Collins Aerospace, FAA, Safe Flight Instruments, CPI-Aero, 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
Deno Jordan	Electrical Eng.		GE - Edison program, Summer 2021	MS, EE U. of Kuntucky
Paramvir Singh	Electrical Eng.		Quadlogic Controls Corp. March 2020 - Hardware Engineer	
Jeffery Apau	Electrical Eng.		Air Force, Sum 2021	
Hassan Saleh	Electrical Eng.		Digatron Power Electronics, Inc, Fall 2020.	
Joan Crus	Mechanical Eng.		Space X, Spring 2021	
Aderet Pantierer	Mechanical Eng.	Boeing, Summer 2019	Northrop Grumman, Fall 2020	
Shmuel Pantierer	Mechanical Eng.	SciMax Technologies, Summer 2019	Northrop Grumman, Fall 2020	
Juan Cruz	Mechanical Eng.	Con Edison – Summer 2019		
Peter Kalaitzidis	Mechanical Eng.		Easy Aerial, Inc.-2020	
Jonahz Hernandez	Mechanical Eng		Precipart, Sum 2020	
Mitchell Werner	Mechanical Eng	SciMax Technologies, Spring 2020	SciMax Technologies, Fall 2020	
Ariel Ferrera	Mechanical Eng	Stryker, Summer 2018&2019	Marotta Controls, Fall 2020	
Brandon Duran	Mechanical Eng	Hudson Technology – Summer 2018 & 2019	Easy Aerial, Inc., Fall 2020	
	Mechanical Eng			
Tatiana Jaimes	Mechatronic Eng.	NASA, Summer 2021		
Samia Oishi	Mechatronic Eng.	Kinetic Communities Consulting, Summer 2019,	Kinetic Communities Consulting,, Summer 2021	
Kastronepaul Thevasahayam	Mechatronic Eng	Pratt & Whitney, Sum 2020	Raytheon, June 2021	
Anil Pathudial	Mechatronic Eng		Tesla, Jul 2020	
Raphael Cordina	Mechatronic Eng	Ecole Centrale de Nantes Summer 2019		
Diego Villegas	Mechatronic Eng		Easy Aerial Inc , June 2020	
Manolo Duenas	Mechatronic Eng.	KG Computech, Sum 2020		

Benavides				
Ramon Martin	Mechatronic Eng.		Technical co-founder ATMIL Inc	
Omomhene Eimunjeze	Mechatronic Eng.	AMTRAK – Fall 2019	Goldman Sachs, July 2020	
Raiyan Mohammed	Mechatronic Eng.		Magellan Aerospace, Spring 2020	
Samantha Vitez	Mechatronic Eng.	NASA propulsion Lab – Summer 2018		
Fatin Saumik	Mechatronic Eng.		Naval Civilian Service–Sum 2020	
Jason Becker	Mechatronic Eng.	EJ Electric - Sum 2017 Brookhaven National Lab- Sum 2019	Brookhaven National Laboratory, Feb, 2021	
Atif Saeed	Mechatronic Eng.	Lockheed Martin, Sum 2019	Lockheed Martin, Sum 202	
Jacqueline Oricchio	Mechatronic Eng.	Rolls-Royce, Sum 2018, 2019	Alken Industries Inc,.Fall2020	
Ryan Lewis	Mechatronic Eng.	SciMax Technologies, Summer 2019	Metis, Fall 2020	
Alyssa Mitchell			Con-Ed – Sum 2020	
Syed Misbahuddin	Mechatronic Eng.		Kearfott Corporation, Fall 2020	
Sagufta Kapadia	Mechatronic Eng.	Lockheed Martin, Sum 2019	Lockheed Martin, Sum 2020	
Juan Aguirre Rodriguez	Mechatronic Eng.	Easy Aerial, Inc., Sum 2018 and 2019	Easy Aerial, Inc., Sum 2020	
Michael Panico	Mechatronic Eng.		Alken Industries Inc May 2020	
Sebastian Andres Valencia Chango	Mechatronic Eng		Secure Wear USA - Production Engineer, Fall 2020	
Gouranga Kundu	MET		ZK Development Corp – Founder and Project Manager	
Tiffany Zavala,			Cyient, May 2021	
Edison Morales	MET		General Dynamics Electric Boat July 2020 – Systems Engineer	
Saminul Chowdhury	MET	General Dynamics Electric Boat, Sum 2019 & 2020	General Dynamics Electric Boat Feb 2021 – Structural Engineer	
Kastrinpaul Thevasahayam	MET	Precision Gears Inc., January 2021		
Jairo Ramos	MET	Easy Aerial, Inc.-Sum 2019 & Sum 2020		
Angel Calderon	MET	Nissan, Summer 2019	Boeing, Fall 2020	
Mohammed Hossain	MET	Raytheon – Summer 2019	Raytheon – Summer 2020	
Abdelmonem Anwar	MET	Pratt & Whitney, 2019	Pratt & Whitney, 2020	
Grace Davis	MET	Daimler Summer 2018 Eaton, Summer 2019	Northrop Grumman-Spring 2020	
Maharshi Patel	MET	NASA-L'Space NPWEE Participant, Sum 2020		
Elsie Ceilema	EET		Aviation Line Maintenance-American Airlines	
Ebon Rockwell	EET	L3 Harris, Summer 2021		
Johnny Jiminez	EET		SafeFlight Instruments	

Autonomous Strategy Planning with Constraints of Tether Robot System

Timothy Tullio
Mechatronic Engineering, Vaughn College of Aeronautics and Technology, East Elmhurst, NY, USA, timothy.tullio@vaughn.edu

Faculty Advisor: Dr. Shouling He
Professor at Vaughn College of Aeronautics and Technology, East Elmhurst, NY, USA
Shouling.he@vaughn.edu

ABSTRACT

The goal of this project is to develop a strategic autonomous routine for a tether robot system for the VEX Robotics Competition, Change Up in the VEX-U division. VEX-U is an international collegiate robotics competition consisting of head to head matches and a "beat the clock" skills challenge. A tournament consists of a series of two-minute matches between two teams employing two robots to out-score their opponents. These two robots must fit into a starting volume 15" cubed and 24" cubed, respectively. This system focuses on the tournament aspect, specifically, the crucial 45 second autonomous period that precedes the 75 seconds of driver-controlled game play. The use of two mobile robot subsystems connected via a length of cables for the 24" cubed robot, introduces an interesting problem in writing a program for autonomous actions, since the tether connecting the two robots becomes a dynamic obstacle in the path of the subsystems, while also maintaining an optimal scoring strategy and ability to counter the opponents. An optimized path to account for these factors is to be designed and then written in C++ using VEXcode Pro V5 IDE to be implemented by the robot.

1. Introduction

The VCAT Robotics Team has competed in VEX-U since the 2008 season. One of the goals of VEX Robotics is to breed many in-depth problem-solving opportunities for students. The way this is done is by annually releasing a new game consisting of multiple challenges and objectives called the VEX Robotics Competition (VRC). The game is played on a 12-foot by 12-foot field consisting of foam tile floor and one-foot high steel and polycarbonate walls as seen in Figure 1. For VEX University Competition (VEX-U), the collegiate division of the VRC, a match consists of a 45 second autonomous period followed by 75 seconds of driver control. This year's game, Change Up, consists of scoring balls 6.3 inches in diameter into nine cylindrical goals that are evenly positioned in a 3 by 3 array (approximately 6 feet in between each goal) as shown in Figure 1[1]. At the end of the match, each ball scored in a goal is worth one point, and every row of 3 goals that has the team's color ball in the top position, also known as owning a goal, is awarded 6 points. The goal of the game is to outscore the opponent by utilizing advanced technological systems and methods.

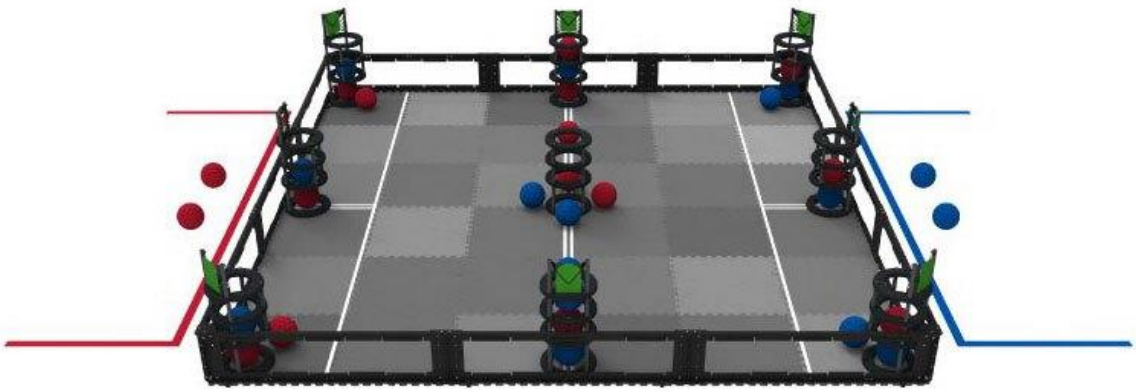


Figure 1. Change Up Field Set Up [2]

1.1. Need Statement

The starting size restriction rule combined with no restriction on the horizontal expansion of the robots once the match begins allows two drivetrains to fit side by side and be used as the larger 24-inch robot shown in Figure 2. This presents a unique mechanics and control problem. If executed well it would create an advantage for the team in a match. Previously AutoCAD alone was used to create two-dimensional drawings of paths based on need. This method does not account for the placement of the tether and optimal path between manipulatable objects, resulting in longer, more inefficient routes.

Figure 2. Tether Robot System

1.2. Objective

Find the most efficient and consistent paths to effectively outscore opponents within the allotted 45 seconds of the autonomous period, abiding by the constraints of the tether robot system. This goal must be accomplished while following the rules set forth by the VEX Robotics Organization in the 2020-2021 Game Manual [1] and according VEX-U Appendix [3].

1.3. Relevant Background

For the 2016-2017 season of the VEX U Competition, the VCAT Robotics Team designed and competed on the world stage with tethered mobile robot systems utilizing the older architecture of the VEX control modules. The autonomous procedures were pre-recorded driver motions where the drivers' inputs were saved and played back during the match [4]. This allows the drivers to manipulate the tether in a predictable manner, without affecting the abilities of the robot during the autonomous period. The pre-recorded code combined with the lack of direct opponent robot interaction created a distinguishable environment for the tether system to thrive.

After watching the live stream in-person events, three main strategies, during the autonomous period of the matches, prevailed for the contestable goals that lie on the "autonomous line" in the center of the field. The first is that teams manipulate these goals early, within 0 to 22 seconds of the match. The next is that those who wait for the last 22 to 45 seconds of the autonomous period score the center goals. Finally, there are teams that do not attempt to own or change the balls that are contained in these goals. These three strategies serve as the foundation for the autonomous routines for each half of tether robot system.

2. Engineering Requirement

i. Create the most efficient and consistent set of paths to effectively score game elements, Figure 3
ii. This path must not interfere with the tether connecting the two subsystems
    a. The robot's path must not run over the tether
    b. The robot's path must not exceed the length of the tether
iii. This path must complete the tasks within the time constraint
iv. The path must be transferable into VEX standard of C++ to be useable by the robot

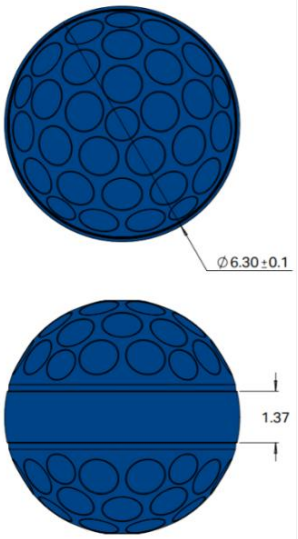


Figure 3. Ball Specifications [2]

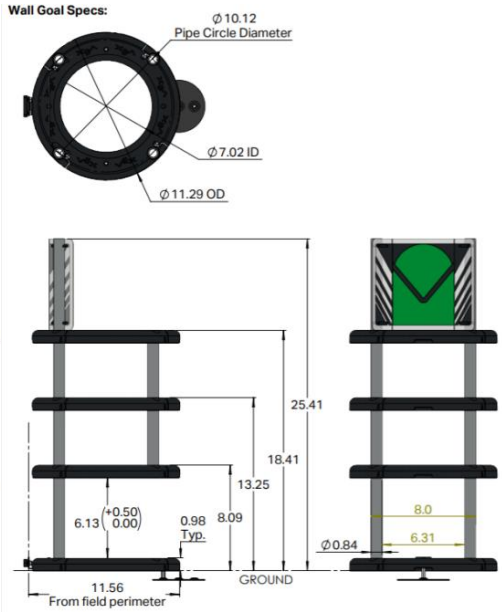


Figure 4. Goal Specifications [2]

3. Engineering Constraints

i. Robot Constraints:
   a. Must use VEX V5 Robot Brain to control the robot and V5 Robot Battery Li-Ion 1100mAh to power the systems [1]
   b. Cannot use more than 20 SmartPorts and 8 three-wire ports on the Vex V5 Brain
      i. 7 motors per subsystem to move and score (14 total smart ports)

1. 4 motors for the drive train (internally geared to 200rpm, with an external gearbox making the output 275rpm)
2. 2 motors (internal gearing of 200rpm) for the intake
3. 1 motor (internal gearing of 600rpm) for scoring conveyor system

      ii. 1 – Inertial (Gyroscopic) sensor per subsystem, returns the orientation of the robot (2 total smart ports)
      iii. 1 - Optical sensor per subsystem to sense the color of the ball moving through the conveyor system (2 total smart ports)
      iv. 2 - Infra-Red, IR, sensors per subsystem to return the position of the ball in the conveyor system (in the bottom-most limit and upper-most limits), a total of 4 three-wire ports
      v. 2 - 2to2 valve solenoid per subsystem to open the intake wider to make the process easier (total 2 three-wire ports with 2 wye-d of connections creating 4-three wire connections)
   c. The path of the subsystems cannot exceed the length of the tether

ii. Path Constraints:
   a. Must complete tasks within 45-second autonomous [3]
   b. Must have a starting expansion routine to expand from the starting 24” cube [3]
   c. Cannot cross the taped double white line in the center of the field (i.e. The Auto line)

4. Mechanical Design

4.1. Drivetrain

In order to meet the width requirement of 24 inches, each half of the drivetrain must not exceed 12 inches. With this in mind, the length has also been made 12 inches for optimal maneuverability and turning ability, shown in Figures 5 and 6. The mode of locomotion was a four-wheel differential drive, due to its simplicity and concise form factor. After testing various gear ratios and output angular velocities, it was found that an internal gearing of 200 rpm with an external ratio of 22:16 created a controllable robot for the driver. This also provided sufficient torque with an output of 275 rpm and 1.53Nm (per half of a drivetrain) [5].

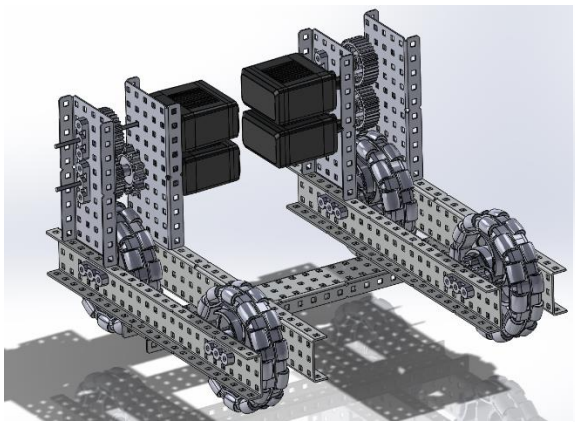


Figure 5. CAD Drivetrain Prototype Front Three-Quarters

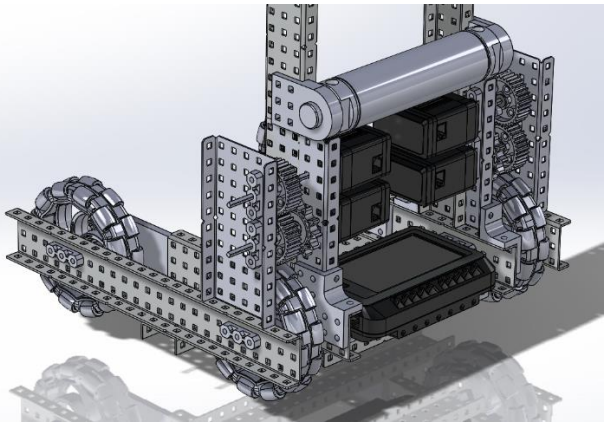


Figure 6. CAD Drivetrain Prototype Rear Three-Quarters

4.2. Conveyor

The main scoring objective for the 2020-2021 game involves bringing the 6.3-inch diameter balls from the bottom of a goal or the ground of the playing field to the height of 18.41 inches. One of the main priorities of the tether robot system is conserving the smart ports of the microprocessor, so only one motor can be allocated to this process. A set of 4 rubber band rollers add an aspect of variable compression on the ball against traction material backing, as it is facilitated through the subsystems, proto typed in Figure 7. The bottom three rollers are driven by a 600-rpm motor with a ratio of one to one between each roller. The fourth and uppermost roller driven to 1200 rpm to give the ball an optimal parabolic projectile path into the opening of the goal by utilizing a 12 to 24 gear ratio [5], seen in Figure 8.

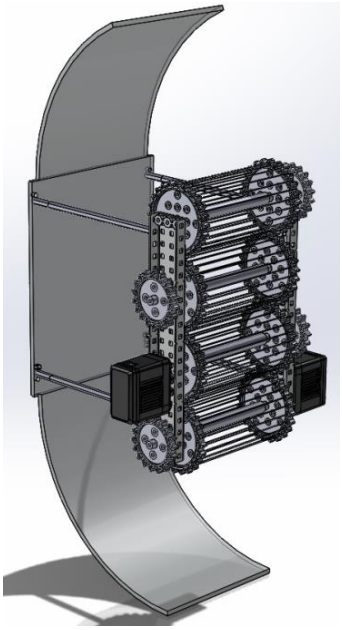


Figure 7. CAD Prototype of Conveyor System

Figure 8. Side Profile of Conveyor System

4.3. Intake

The intake consists of four three-inch diameter VEXPro straight-flex wheels to facilitate the scoring elements into the robot, with one 200rpm driving each side. Single-acting pneumatic pistons increase the angle between the 3-D printed, which diminishes the precision needed to gain possession of the ball around the field and in goals [5].

Figure 9. Closed Intake, Default Case

Figure 10. Open Intake, Actuated Case

5. Bending Stress Analysis of Robot's Standoff

Four Robot's standoff will support approximately a total of 2 lbs load at the free end due to four rollers, four axels, two support aluminum C channels and one VEX motor. Hence each 6.5 inch length standoff will support approximately 0.5 lb and will exert a bending stress to the frame of the robot that is in contact with standoff.

5.1 <u>Standoff Safety Analysis:</u> Bending stress due to weight of attachments at the free end hollow standoff can be expressed as

$$\sigma_{applied} = \frac{M * C}{I} \quad (1)$$

Moment due to Smaller Robot weight at end of piston is

$$M = F * L \quad (2)$$

Where, F = 0.5 lb, L = 6.5 in. Hence, moment at the fixed end can be expressed as

$M = 0.5\ \text{lb} * 6.5\ \text{in} = 3.25\ \text{lb} - \text{in}$

The moment of inertia of hollow standoff is

$$I = \frac{\pi}{64}\left(d_o^4 - d_i^4\right) \quad (3)$$

Where, d_o = 0.25 in, d_i = 0.14 in

$I = \frac{\pi}{64}\left((0.25\ \text{in}^4) - (0.14\ \text{in}^4)\right) = 1.729 * 10^{-4}\ \text{in}^4$

Outside distance to center of standoff is:

$$C = \frac{d_o}{2} = \frac{0.25}{2} = 0.125 \text{ in} \quad (4)$$

Hence, bending stress at the fixed end of standoff can be calculated as follows:

$$(\sigma_{\text{Applied}}) = \frac{(3.25 \text{ lb} - \text{in}) * (0.125 \text{ in})}{(1.729 * 10^{-4} \text{ in}^4)} = 2.35 \text{ ksi}$$

Factor of Safety of standoff under applied stress can be expressed as:

$$FS = \frac{\sigma_{\text{ultimate}}}{\sigma_{\text{applied}}} \quad (5)$$

Where, $\sigma_{\text{ultimate}} = 65$ ksi and $\sigma_{\text{applied}} = 2.35$ ksi, $FS = \frac{65 \text{ ksi}}{2.35 \text{ ksi}} = 27.7$

This indicates that standoff has a high factor of safety relative to ultimate strength, and hence it can safely support the weight of all attachments.

6. Programing and Software Design

6.1. Autonomous Functions and Routines

Functions to manipulate the balls were created in the VEXCode Pro V5 software. The functions to manipulate the game elements using an infra-red sensor were completed for the following: intaking balls, scoring balls into the goals and emptying the unwanted balls from the robot by reversing the conveyor. Functions for the movement were also created, a straight-line motion based on encoder rotations and turning about a single point using an inertial management unit. Each of the movements has two pass parameters, either a distance (inches) or absolute heading (in degrees) and the speed (in terms of percentage power) of the motor rotation. These functions were duplicated and modified to suit both subsystems.

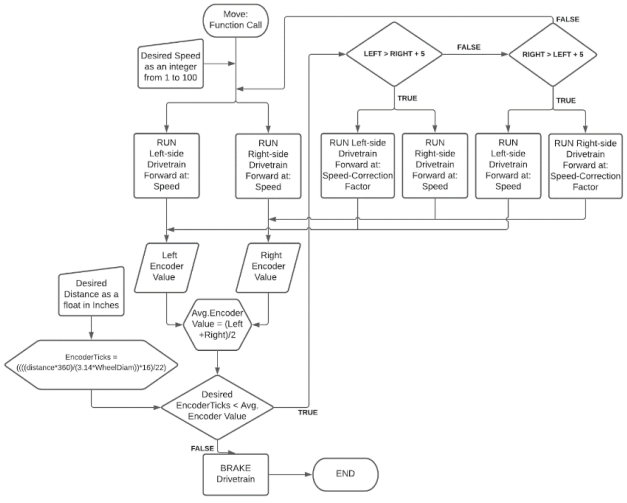


Figure 11: Move Forward Logic Diagram

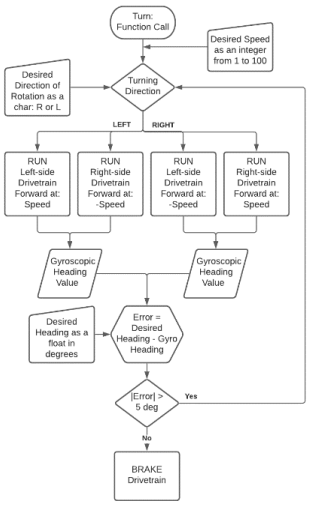


Figure 12: Turning Logic Diagram

Using the functions mentioned above, autonomous routines were created for each half of the robot. These routines are collated in "tasks", so the subsystems can move and score almost simultaneously to the human eye. This synchronization is done through the process of Semaphores which allow each function to yield to the other after completing a line. Flags, variables with data type "semaphore", are set in order to regulate when each function will be sent to the single core processor [6].

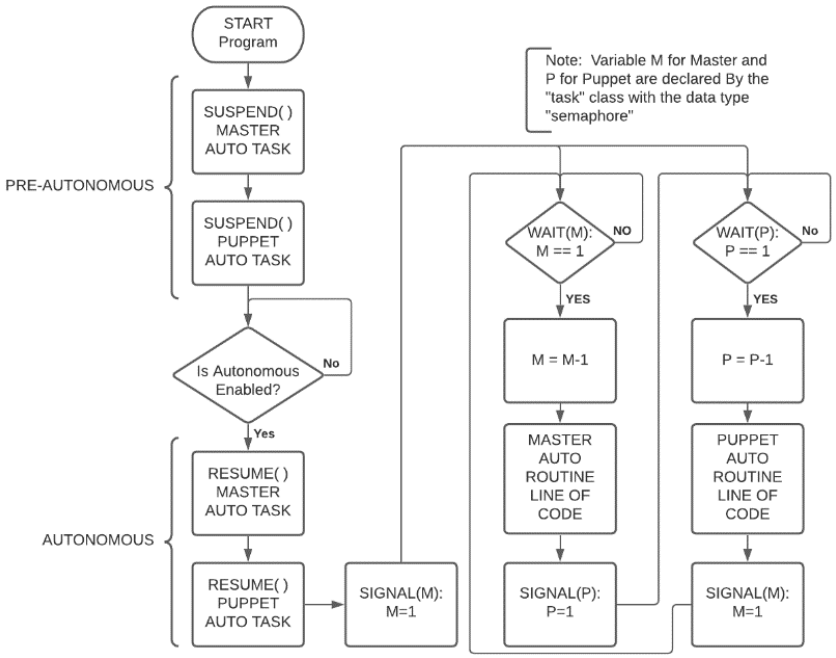


Figure 13: Autonomous/Task Logic Diagram

6.2. A Star Algorithm Research

One of the methods researched was the A*(A Star) method. This algorithm finds the most ideal path between a starting point and a goal coordinate by calculating the cost valve for the robot to move to the next point and the estimated cost to move to the goal based on the new point [7]. This cost can be modeled as the equation:

$$F = H(x) + G(x) \qquad (6)$$

Where F is the total cost of moving to the target node, H is function estimating the cost to move to the goal node, G is function calculating cost for moving between the previous node and the current node, and x is the set of parameters affecting the cost

The decision was that this method of determining the path would be too time-consuming to integrate synchronous cost budgeting based on the pose with respect to each half of the respective orientation, the distance between the subsystems, and the proximity to the game elements to be manipulated.

6.3. Kinematic Diagram Research

6.3.1. Field Plot

An accurate representation of the field in a MATLAB plot, based on the specifications provided by the VEX Robotics Competition in Appendix A of the 2020-2021 game manual, was created to validate a kinematic model. Goal and ball diameters are within specification and placed in the proper locations about the quarter of the field within which the tethers operate. The units of the plot are inches and are indicated on the axes.

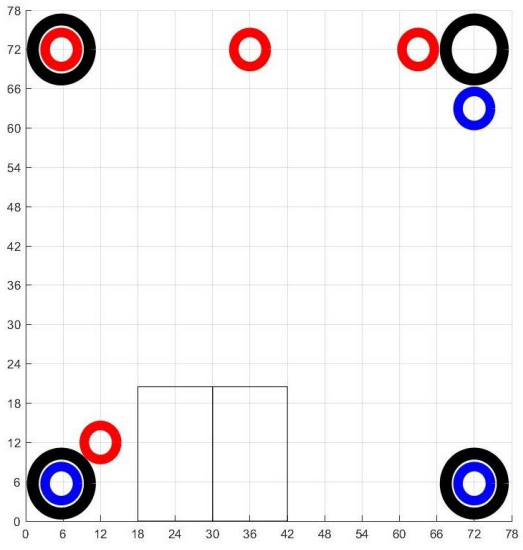


Figure 14: MATLAB Plot of the Field

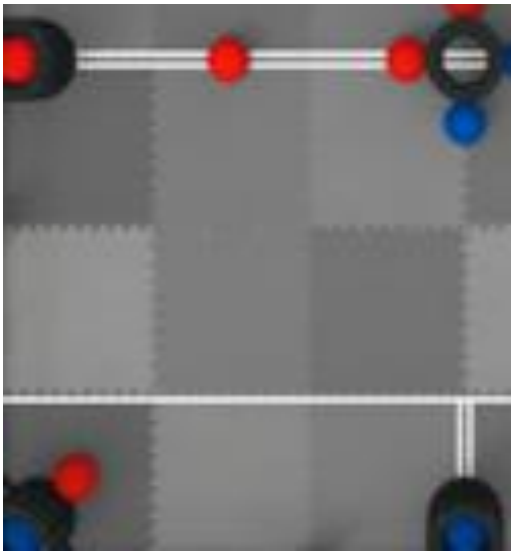


Figure 15: Top/Down Field Graphic [2]

6.3.2. Kinematic Diagram/Time Data

Using a timer, values were stored into an array after every significant event in the path. The stored values were saved into a header(.h) file on an SD card that is removable from the microprocessor. The time values were used as the foundation for the kinematic plot of the subsystem paths across the field. Due to the nature of an unsigned integer variable, storing values less than or equal to the value 255, the data collected did not accurately represent time spent by the robot completing function calls during its routine.

6.4. Autonomous Strategy

Taking the methods used by the A-Star to calculate goal priority and Kinematic Diagram's ability to visualize the length and angle of the tether will be applied to strategic path planning.

6.4.1. Designed Path #1

For this year's season, there is an emphasis placed on completing the "Home Row" during the 45 second autonomous period, with competition standing points awarded to the teams who are able to "own" the row three of the goals closest to their starting position. The second highest priority is to fill center goal; should the opponent not score any one of their home row goals, it would cause another row to be scored for our team. This first combined path focuses on consistently and quickly scoring these crucial goals.

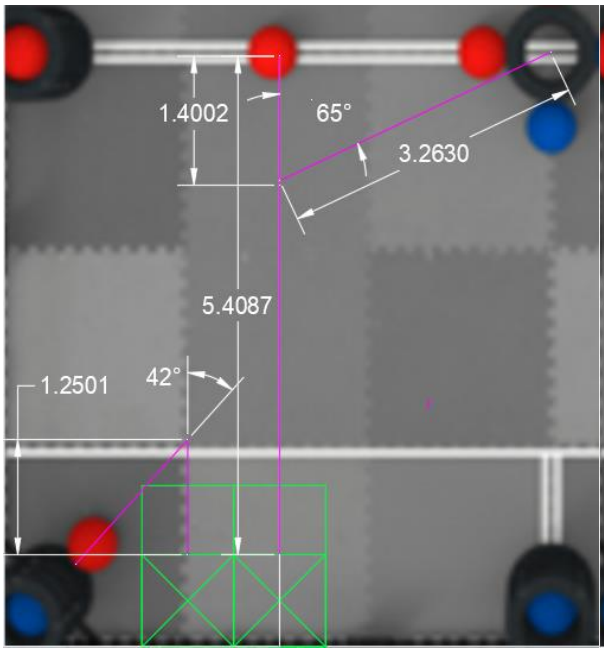


Figure 16: Path #1 with dimensions in feet and degrees

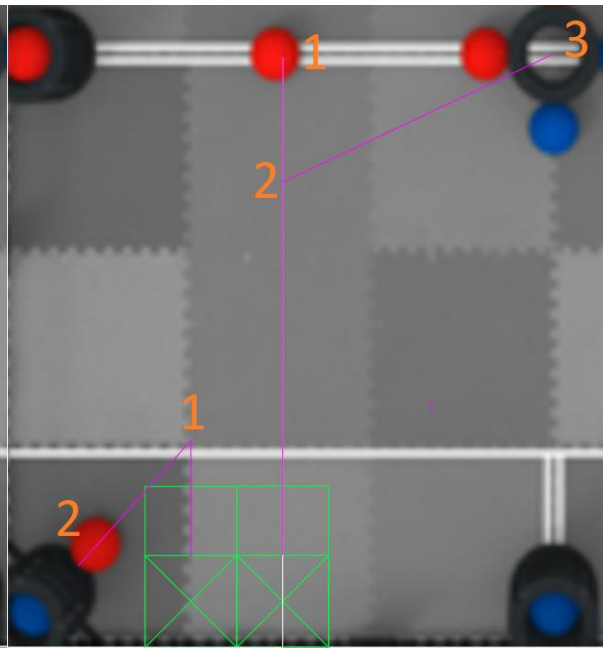


Figure 17: Path #1 with the order of completion

The magenta lines represent the path taken by the according subsystem based on their initial poses, as detailed by the green rectangles at the bottom of the images. The resulting path used to complete the scoring and move to the final positions encompasses a total of approximately 11 seconds, 12 function calls for master subsystem(left), and 9 function calls for puppet subsystem(right). This path satisfies the case for when the left middle is uncontested and the center goal is contested during the first half of the autonomous.

6.4.2. Designed Path #2

Building off of the first path, the attention of the subsystem on the left turns toward the middle left goal to play defense and ensure that it stays scored in favor of our team for the end of this period of the match. This is done by cycling the opponent's color ball to the bottom of the goal from the middle position and parking in front of said goal. Keeping this goal filled and our final position does not allow the opponent to add scoreable balls to the goal. As for the right subsystem, it returns to the home row and bottom middle goal to remove the opponent's ball. The VEX U matches are highly competitive, and the removal of a single point from the opponent makes the difference between winning or losing the autonomous bonus points. With this in mind,

the next move for the right subsystem is to return to the middle goal in the home row to remove the opponent's ball.

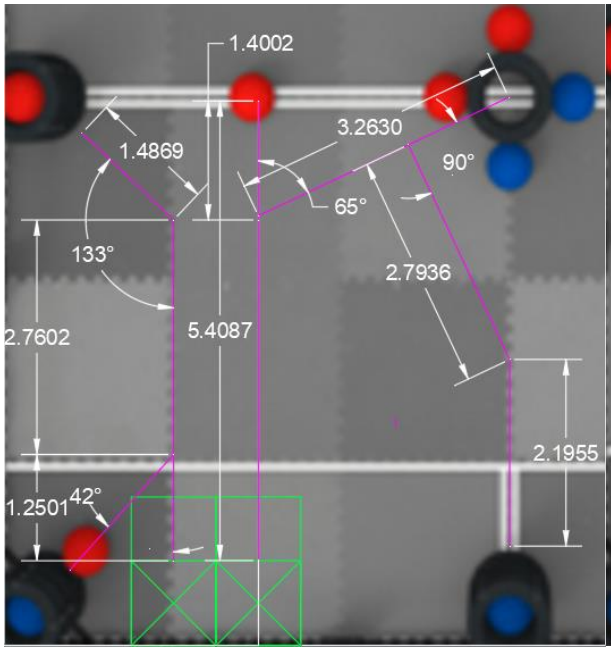


Figure 18: Path #2 with dimensions in feet and degrees

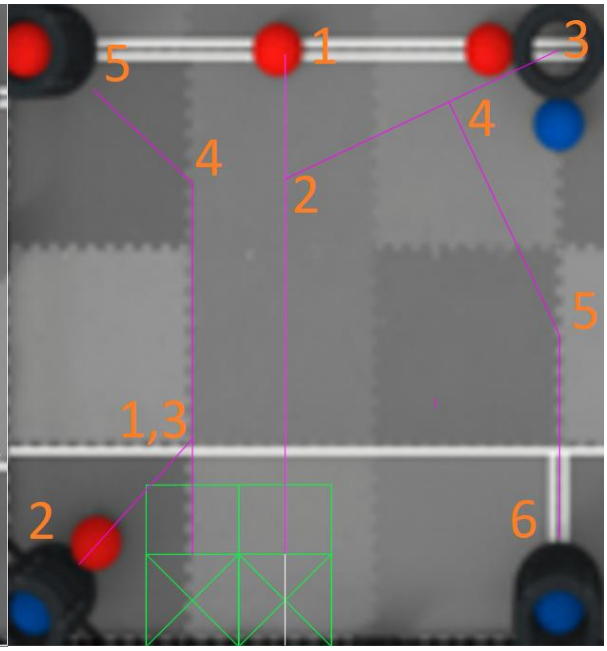


Figure 19: Path #2 with the order of completion

The path described above in Figures 18 and 19 is completed in a total of approximately 21 seconds with 18 function calls for master subsystem, and 19 function calls for puppet subsystem. This path satisfies the case for when the left middle is contested early in this period and when the center goal is uncontested during this portion of the match.

6.4.3. Designed Path #3

The tertiary plan is made in anticipation that the center goal will be contested after the time that the right-side subsystem had placed 3 balls into it. Instead of the right subsystem going to the bottom to de-score, it will take one of our team colored balls and return to the center to add it to the goal with the minimal amount of time left in this section of the match. A similar strategy is applied to the left sub system, in which a ball of the team's color will be carried toward the middle-left goal and waits at point 4 until the last 2 seconds of the period to initiate scoring.

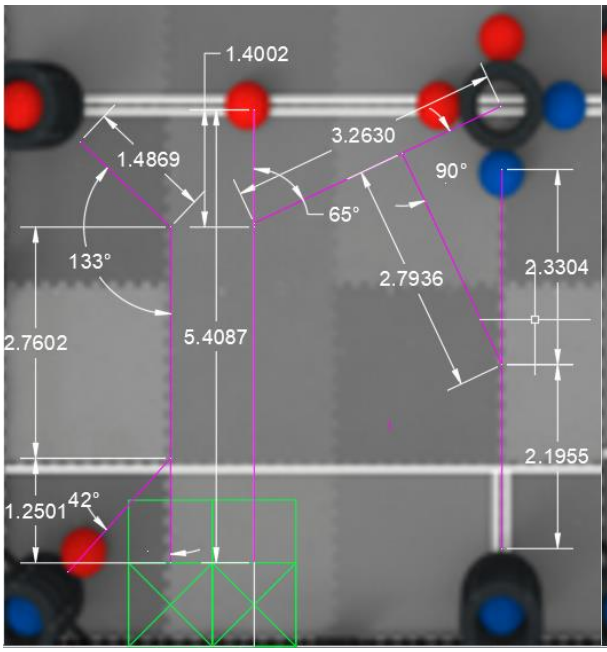


Figure 20. Path #3 with dimensions in feet and degrees

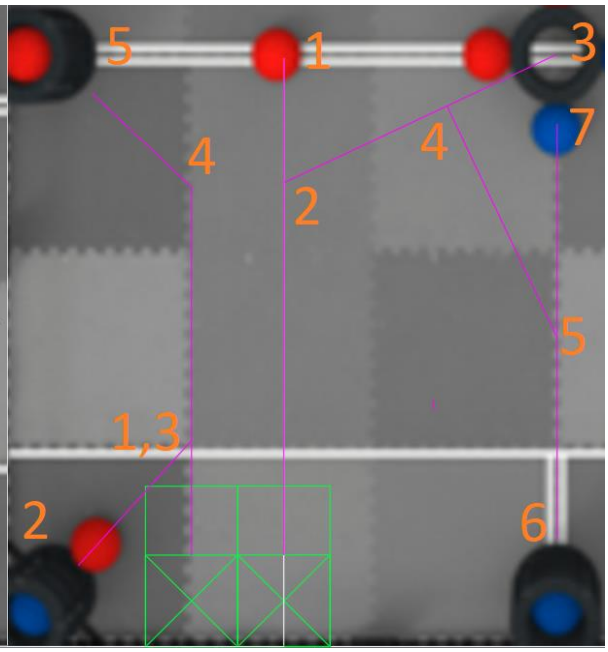


Figure 21. Path #3 with the order of completion

The path pictured above in Figures 20 and 21 fills the full forty-five seconds of the autonomous period with 17 function calls for master subsystem, and 21 function calls for puppet subsystem. This path satisfies the case for when both the left middle and center goal are contested during the second half of this portion of the match.

7. Impacts

7.1. Social Impact

The advancement of networks multiple mobile robot systems are becoming more prominent within the industry, bringing a higher quality of life to workers by removing arduous repetitive tasks.

On a smaller scale, the social goals are to promote STEM for Elementary, Middle, and High School students in order to inspire the next generations of engineers, as well as to provide a solid platform for Vaughn College to reach those future generations of engineers. A further goal is to produce an environment for the current Robotics Team members to expand their knowledge and flourish as aspiring engineers.

7.2. Economic Impact

The use of autonomous tether robots decreases the need for the mass production of microprocessor chips, by replacing multiple individual mobile robot systems for a single processor tether-based system. Making this switch in approach decreases the cost to implement

each system, which also decreases the investment needed for a company to implement multiple mobile robots to their work environment.

8. Conclusion

Advanced strategic autonomous path planning would be advantageous for the team, from a competition standpoint, by providing the most efficient and effective route for the tethered mobile robot system. The VCAT Robotics 2020-2021 Team has qualified for the VEX Robotics World Competition through achieving the Excellence Award and the top score separately in Virtual Skills competitions. The team is anticipated to participate in the World Competition June 25th and 26th 2021 in Greenville, Texas.

9. Acknowledgement

The author would like to acknowledge their faculty advisors, Dr. He, Dr. Rahemi, Prof. Tang, Rachid Nafaa, Alaric Hyland, and the Vaughn College Department of Engineering faculty for their technical support. Also, I am thankful to the HSI-STEM title III grant for the funding support of this project as well as VCAT Robotics team for supporting the project mechanical development.

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11. Authorization & Disclaimer

The author authorizes Vaughn College to publish the paper in the Vaughn College Journal of Engineering and Technology. The Authors are responsible for both the content and the implications of what is expressed in the paper.

Handle Shield: Door Handle Limited Contamination Device Mechanism

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ABSTRACT

The Handle Shield is an electronic object that will be used as a layer of protection between one's hand and a physical door handle. The reason for this protection is not to protect against the handle itself, but to eliminate, by a significant degree, the number of germs spread from touching the same surfaces. Germs can last for hours on one's hand. The design of the Handle Shield is simple. The device will eliminate the contact between one's hand and a physical door handle using a thin sheet of plastic (something as thin as a grocery bag). To open the door, you would first contact the film and then grip the door handle to open and once this process is over Handle Shield will then release a new film, so the process could then repeat. The Handle Shield will be designed for places with a high volume of commuter traffic, both in and out, but could be used in places with little to no traffic at given times. It would be placed ergonomically on a door, not affecting or reducing the operation of the door and can easily be disregarded if no longer needed, for a given period. The design will look something like a small box above the door handle and one below, distant enough so that in the process of opening the door, no contact will be made with either of the units.

1. Introduction

Poor sanitation is believed to be the cause of 432,000 deaths each year [8]. A doorknob contains many germs and bacteria, because many people touch it on a regular basis. In 2020, there was a pandemic outbreak that caused some cites to lockdown and many businesses to close. It caused public distress because the disease was novel and easily spread. This called for the need for more sanitary door handles. With a handle cover the spread of disease is less, because doorknobs will be protected and thus more sanitary. Since each time it is going to be used there will be new

plastic to cover the doorknob, the spread of germs and bacteria is less likely to occur. A further benefit is that the public will be less fearful of contacting disease.

A sanitary doorknob allows people to use door handles without worries of germs and bacteria. One sanitary doorknob is the hands-free door opener. This is a device that allows people to open doors without using their hands. One design is a handle that allows the person to open the door by using his/her forearm. The person opens the door by pulling it back with his/her forearm [6]. Another design is a plate attached to the bottom of the door [3]. People would open the door by pulling it back with their foot. Both are bolted onto the door. Another sanitary doorknob in the market is the Cleanhandle. This device sprays the handle with an anti-bacterial aerosol that quickly dries. It uses a vibration sensor that activates it ten seconds after the door is opened or closed [2]. It is attached to the door with adhesive pads. Because of its design it does not fit all types of door handles. It can only be used on door level type handles. The Handle Attendant takes a different approach. It uses UV light to sterilize the door handle after each use. The UV light turns on for 15 seconds after using the handle and then goes into battery saving mode. The UV light kills 99.9% of germs, viruses, and bacteria in seconds [7]. It consists of two UV light fixtures that are mounted above and below the handle. Since each unit is $400 dollars, the use of this device is prohibitively expensive for many companies.

Most products available are used on push/pull doors, where turning a handle/knob is not required. Many doors require people to turn the knob. The Handle Shield is an easy installation door handle cover. It covers a doorknob handle with a film and replaces the film, every time the handle is used. It helps reduce the spread of germs, bacteria, and diseases and can be used on many types of door handles.

2. Standards

2.1 Programming Language

The Handle Shield device will use Arduino C programing to control the device; it will run in a Loop with inputs driven from door usage. Simple Changes can be made to the programing if needed, or just by replacing given parts if possible and affordable.

2.2 CAD Files

The body of the Handel Shield will be done by a 3D-Printer. CAD files must follow 3-D printing guidelines. Files must be converted into a STL file and measurements unit must be in millimeters. The drawing views for every piece of the Handel Shield will be displayed.

2.3 Drawing Files

Drawing files follow ASME Y14.100 and ISO 128 standards. ASME Y14.100 are the standards for engineering drawings and practices of the American Society of Mechanical Engineers. ISO 128 are international standards for technical drawings. It is important to follow these standards, so that people worldwide will understand the geometry of the parts.

3 Environmental Impact

It is not possible to take into account each and every environmental regulation. In some cases, cost data will lack, as well as most recent regulations. However, it is possible to focus quantitatively on the most significant problem we are all facing now, the Covid-19 virus. Since the application of this device will be used a lot, it will create more waste product. The more traffic a door gets the more waste it will produce. By having a biodegradable or recyclable plastic film, the effect on the environment will be limited. Many people wear disposable gloves that are thrown away in the trash. This affects the environment. The Handle Shield will help reduce the number of gloves used with a recyclable material, thus limiting the environmental hazard.

4 Economic Impact

Businesses will grow because this product will reduce the spread of bacteria, germs, and viruses. Fewer people will get sick from this virus. In pandemic times, people are afraid of contracting disease, however with the Handle Shield people will feel safer. Users will not have to keep worrying about doorknobs being contaminated. In addition, a single contaminated handle could affect many workers and customers. By reducing the spread of bacteria, germs, and virus, more people will not be sick. The cost of the Handel Shield will not be high, which makes it more accessible than other expensive products like the Handel Attendant, for example.

5 Design Concept

5.1 First Iteration

In the first phase of the design process, the idea was to use an SW-420 motion sensor. The goal of the motion sensor was to provide feedback that will tell the system it is time to lay out a new film. Issues were encountered, such as the motion sensor detected any kind of motion, not just human motion from opening or closing a door. Many things move in front of doors, such as people passing by or even small particles. A good example of this is when one passes very close to a sliding door at the mall; although one is not using the door, the door opens anyway due to motion detection. The Handle Shield in this case would be critically wasted.

Issues regarding the Motors were also encountered. The motors programmed to run for a set amount of time, in order to provide a new layer of film along the entire door handle. As the CAD files were made and configurations were discussed, a problem with the motor regarding the collection of the waste film was apparent. Over time, the roller collecting the film increases in circumference, due to the cumulation of the rolling film, therefore setting the motor to run for a set time would make the pulling distance of film vary greatly from the beginning to the end.

5.2 Modifications in Iteration I

The motor had to wait until the vibration stopped. When the system detected the first vibration, it would only wait the initial 5 seconds and then run the motor. If there was a second vibration, the motor would still run. Another issue was the amount of film the motor pulled was insufficient.

Also, the film warp was larger than the original design. It did not fit properly into the design. Furthermore, whenever the system was running, gear slippage was present. The gears were not working properly. Lastly, the gears had a tight fitting which did not allow the motor to rotate the gears.

To accommodate these issues, a check code was added to the code shown.

```
void CHECK()
{
  for(i=0; i<= 100; i++)
     {
        digitalWrite(led, !digitalRead(led));
        delay(50);

        if(digitalRead(vibration)==HIGH)
        break;
     }
}
```

Figure 1: Check Loop made for Correction

The gears were made thicker to prevent gear slippage. The roller mounts had to be taller, because the gear and film would sometimes scrape the base. Because of the tight fitting between the gears, the holes on the motor mount were elongated in order to move the gears further away from each other. Additionally, the side of the motor mount had to be filed away to accommodate the movement of the gear.

5.3 Iteration II

In order to correct the issues discussed and analyzed throughout the first iteration stage, a new method of determining what will set off the system in order to provide a new film layer was decided on. The job would be done using a Vibration sensor. The vibration sensor will allow the system to observe for heavy vibrations (doors opening and closing) and to dispense a new film once the vibration stops, after a set period of time (Once the door has been used and closed).

As for the motor issue discussed in the first iteration, a rotary encoder module will be added to the Handle Shield. The job of Rotary Encoder will be to control the motor. The Encoder will be installed in the entry slot to the lower receiving unit and will roll freely with the film allowing it to read how much film is passing. The Encoder will then be programed to read the set amount of film needed, and when that quantity is satisfied, it will then shut off the motor. This action will completely surpass the issue of a varying circumference change of the waste collection roll.

5.4 Modifications in Iteration II

The encoder shaft will be issued when disposing the plastic film to the base unit. In this case, the plastic film will squeeze after it has been used on the door handle; therefore, there will be an error disposing the plastic film passing through the encoder shaft. Another error that came up was the gear roller and its functions. The plastic film forms a slack inside the unit between the

gear roller and the encoder shaft. We needed the slack to be on the outside to be able to hold the door handle with full effect. Also, after the plastic film had been use, it would form too much roughness on the roller gear and defeat the purpose. Changing the plastic film type to have less stickiness to the door handle helps dispose of the plastic film as smoothly as possible. Keeping in mind the purpose of this hand shield device, leads us to eliminate the part of the code that pushes back the plastic film to create the slack between the upper and base unit after. The reason for this is that the inside of the lower base unit is already contaminated, and the disposed plastic film has already touched the parts inside, before it then brings it back out to form the slack, thus defeating the purpose of the prevention of germ spread.

A few changes are needed to fix this issue. First, we must eliminate the Encoder and the roller gear out of the project design. Adding two gears to the design is another option, as well as adding to the programming function. The motor gear will be placed by the entrance of the lower unit base to collect the disposed plastic film. In this case, the lower base unit is used as the waste basket where the used plastic films will be placed. The second motor will be placed to the upper unit to dispense the plastic film. The top and bottom motors will run at the same time, in the same direction as the previous program. What will change in this case is that the motor in the upper unit code will be given additional time to dispense the plastic film, to create the slack after the motor in the lower unit has stopped. The finite element analysis sample for the Roller mount was solved by hand and on Patran-Nastran.

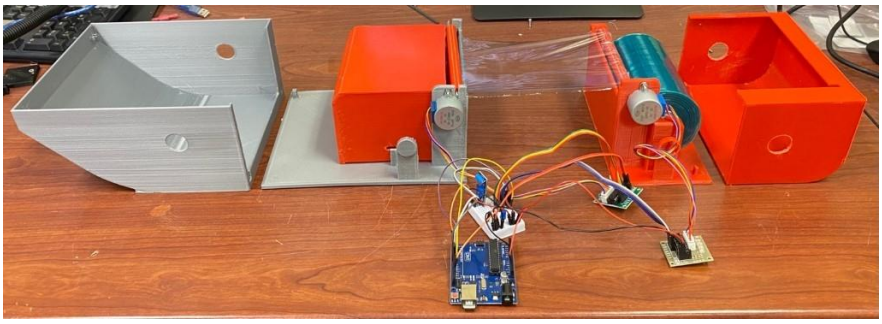

Figure 2: Iteration 3 Final Prototype

6 Programing System Control Unit

The desired coding language for Handle Shield was Arduino C. The reason Arduino was chosen was because Arduino products are widely available. Also, the sensors that Arduino has available under their platform can easily be modified, added to, or subtracted from for product compatibility. The final design iteration used 2 motors and one vibration sensor. The code break-down is shown in the figure below.

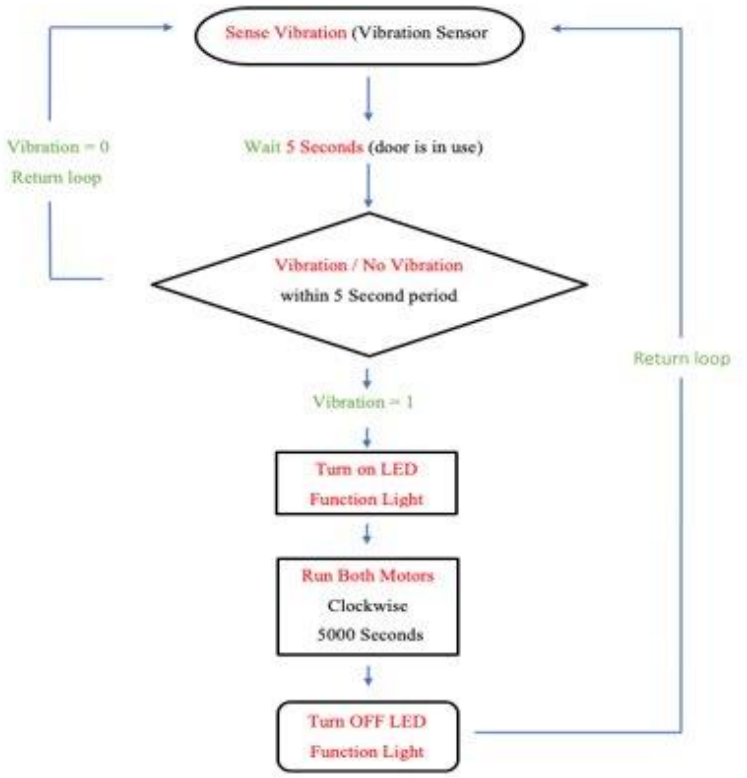

Figure 3: Code Diagram

7 Structural Analysis

7.1 Hand Calculations

In the worst-case scenario, the roller will be subjected to a distributed load from the weight of the film and a distributed load because of the tension of the film being pulled. Both will be in the same direction. The motor can produce a maximum tension load of 25.38 N/m on the film. The motor's max torque at .07936 rev/s is .038Nm [4]. The motor in the Handle Shield will run at a similar speed. The max torque of the motor will be 0.04 Nm. In a negative scenario, the film roll may jam not allowing it to move. The torque was divided by the radius to find the tension. The analysis will be done for a roller with both ends fixed.

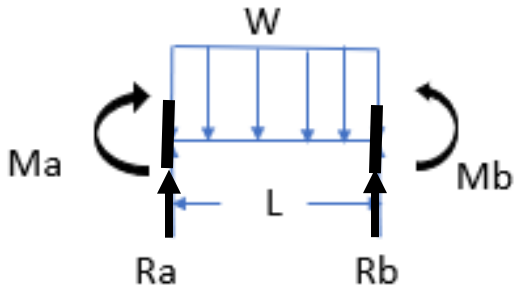

Figure 4: Free Body Diagram of Roller with both ends Fixed

T = Tension of the film; 24.84 N/m

S = Weight of the film; 95.29 N/m

H = Height of the roller; 0.00584 m

L = Length of the roller; 0.140 m

W = T + S = 120.13 N/m

R = radius of the roller; 0.0115 m

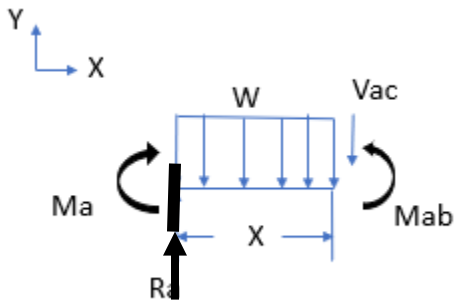

Figure 5: Cut Between A and B

$$Ra = Rb = \tfrac{1}{2} WL,$$

$$Ma = -Mb,$$

$$\Sigma Fy = 0; \; - Vab + Ra - WX = 0$$

$$Vab = Ra - WX,$$

$$\Sigma Mab = 0; \; Mab - Ma - RaX + WX(X/2)$$

$$Mab = Ma + RaX - (\tfrac{1}{2})WX^2$$

$$EI\,(d^2Y/\,dX^2) = Mx,$$

B.C: $X=0, \theta=0; \; X=0, Y=0; \; X=L, \theta=0; \; X=L, Y=0,$

$$EI\theta = \int Mx, \; EIY = \iint Mx,$$

$$EI\theta = MaX + (\tfrac{1}{2})RaX^2 - (1/6)\,WX^3 + C_1$$

$$EIY = \tfrac{1}{2}MaX^2 + (1/6)\,RaX^3 - (1/24)\,WX^4 + C_1X + C_2$$

$$[X=0, \theta=0] \;\; C_1 = 0, (1)$$

[X=0, Y=0] $C_2 = 0$, (2)

[X=L, θ=0]; $MaL + (½)RaL^2 – (1/6)\ WL^3 + C_1 = 0$ (3)

[X=L, Y=0]; $½MaL^2 + (1/6)\ RaL^3 – (1/24)\ WL^4 + C_1L + C_2 = 0$ (4)

Multiply eq. (3) by 1/3 L and subtract eq. (4).

$-(1/6)\ MaL^2 - (1/72)\ WL^4 = 0$

$-(1/6)\ MaL^2 = (1/72)\ WL^4$ $Ma = – (1/12)\ WL^2$,

$Ma = – (1/12)\ (120.13\ N/m)\ (.14\ m)^2 = – 0.19621\ Nm$

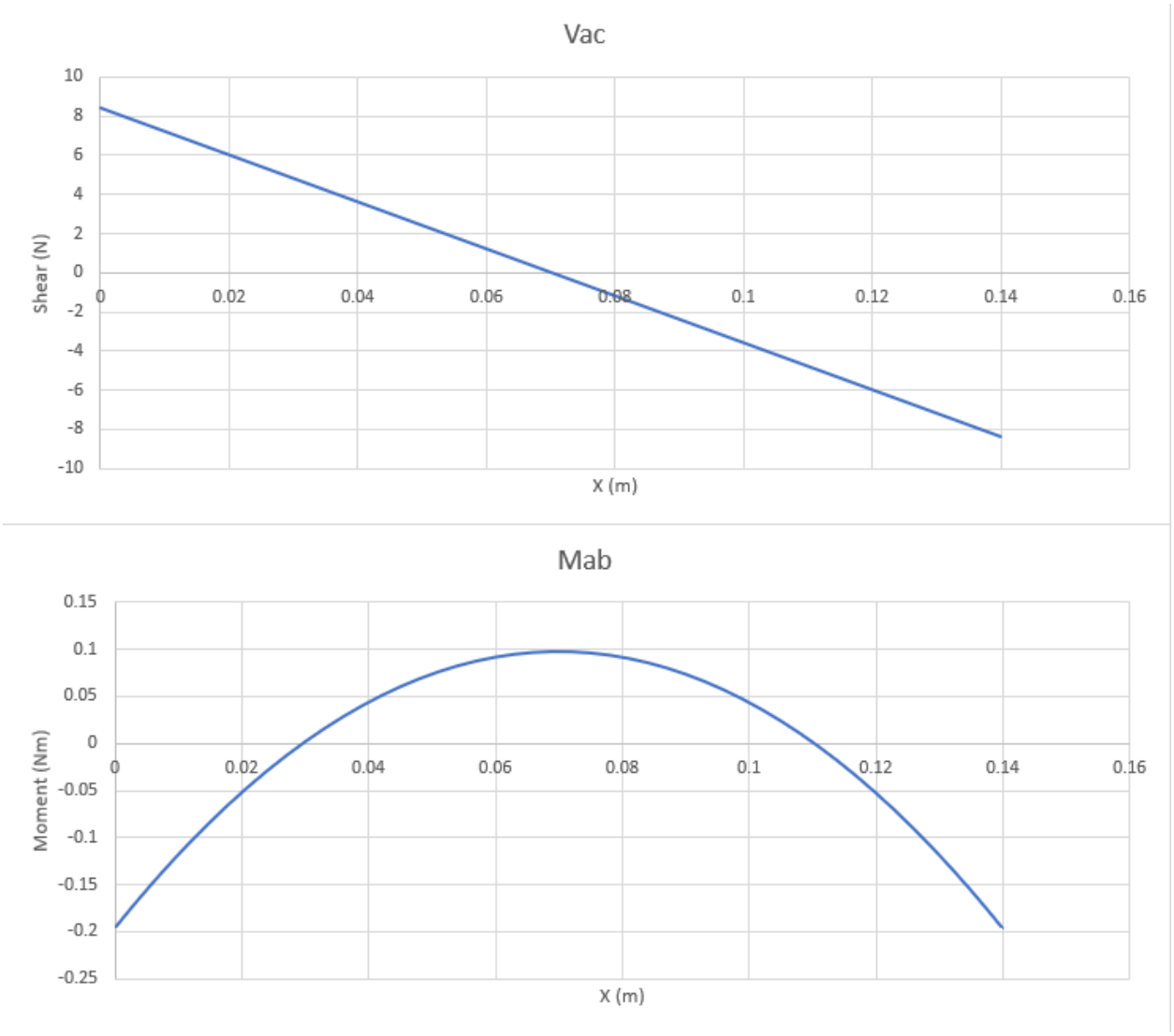

Figure 6: Shear and Moment Diagram

The maximum stress is located where the shear and moment are the largest. According to figure 6, the max stress will be at the end of the roller.

$$\tau = VQ/It$$
$$Q = A^1 * y^1 = (½)\pi r^2 * (¾)\ r/\ \pi = 1.0139*10^{-6}\ m^3$$
$$t = 2*r = 2*\ 0.0115\ m$$
$$\tau = 26.99\ KPa$$
$$\sigma = -\ My\ /\ I = 0.1643\ MPa$$

The stress is maximum at the end of the roller. The max stress calculated is 0.1643 MPa.

7.2 Finite Element Analysis Using Patran-Nastran

A sample for the finite element analysis (FEA) of the Roller Mount design for Iteration 3 was done on Patran-Nastran. An issue was encountered, because whenever the loadings are applied they apply in all directions. The loadings should only be in one direction. The type of plastic material used for the sample is ABS. More about the properties is shown in figure 7 below. Number of forces was applied pulling down in one direction. The Roller is fixed at both ends.

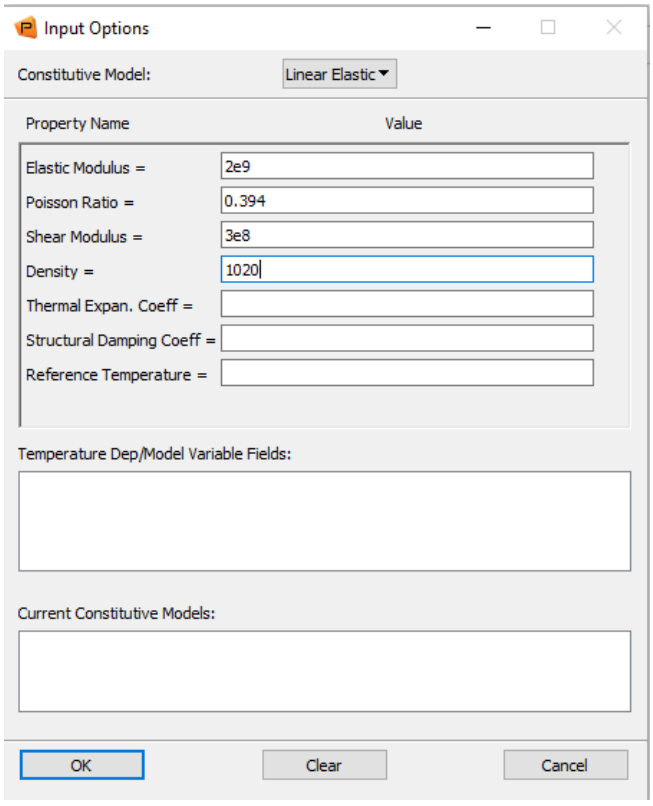

Figure 7: ABS Material Properties

The following loading conditions were applied.

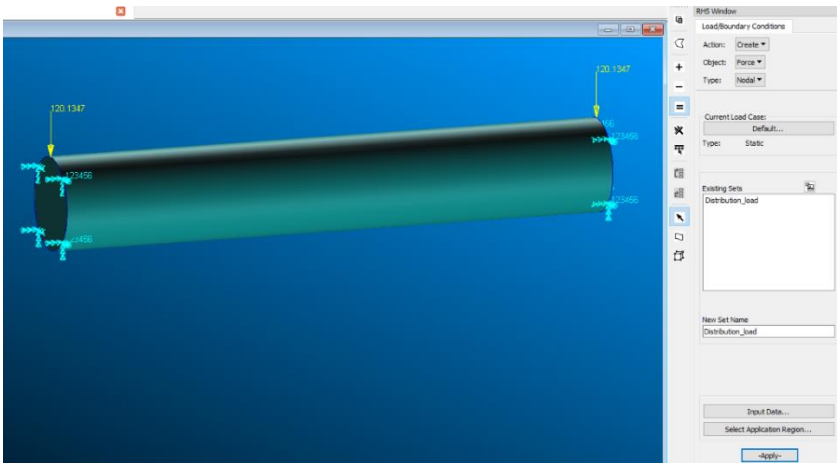

Figure 8: Loading Conditions on Roller

Result of the loading conditions.

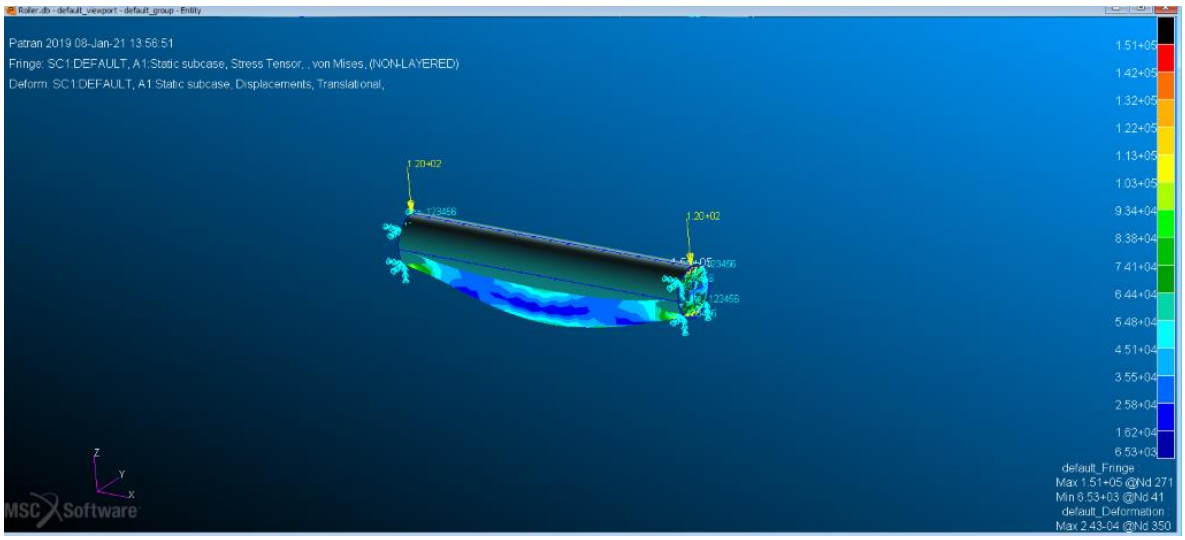

Figure 9: Results of the Finite Element Analysis

According to figure 9, the max stress is found at the ends of the roller. The max stress is 0.151 MPa.

7.3 Factor of Safety

The max stress calculated by hand was 0.1643 MPa and the max stress found using Patran-Nastran was 0.151 MPa. They are within 10 percent of each other. To calculate the factor of safety, the larger stress will be used.

Yield Stress of the material is 30 MPa.

Factor of safety: $N_{fs} = \sigma_{yield} / \sigma_{allow}$

$N_{fs} = 30 \text{ MPa} / 0.1643 \text{ MPa}$

$N_{fs} = 182$

The factor of safety is 182. It is well above the desired factor of safety of 2. The factor of safety of 2 was desired, because 2 is generally used.

8 Estimated Cost

The Handle Shield would have to come at an affordable price, somewhere below fifty dollars a unit. According to table 1, to manufacture one unit it costs slightly above thirty dollars; however, when mass producing, the price will drop to less than nine dollars.

Table 1: Estimated Cost of Input Devices

Item	Cost (single)	Cost (300 + Units)
DC – Stepper Motor	$ 4.50	$ 1.20
Vibration Sensor	$ 1.40	$ 0.45
Wiring	$ 0.12	$ 0.02
Rotary Encoder Module	$ 1.80	$ 0.34
Material (Plastic; Base, Gears, Outer shell)	$ 3.00	$ 1.50
Plastic Film	$8.00	$2.00
Micro Controller	$12.98	$ 2.99
Total	**$31.8**	**$8.50**

9 Conclusion

The Handle Shield was designed using CAD software for drafting and running simulations. Arduino units were also used in order to generate power and control to the motors, with responses from the sensor. Meetings occurred on a weekly basis with Dr. Amir Elzawawy to inform new findings and to ensure fluidity with present time frames. Feedback and more efficient ideas will be strongly taken into consideration. The team used their Engineering judgement, knowledge, and understanding while employing engineering principles.

10 Improvements

10.1. 3D Print Modeling and Resolution

3D printing works by depositing layers over layers of thermoplastics to create a 3D object. Using this method of modeling means each brand-new layer of modeled material must be supported by the layer below it. When a model has an overhang, meaning it is not supported by anything

below, the 3D printing software will create a support structure to ensure a successful print. Supports are an absolute necessity when it comes to most of models, for cut outs, over hangs, bridges etc. They come with a downside, however, because supports not only increase cost due to an increase in material use, but there are features that must then be cut away using tools which can create imperfections in the model's surface. Cutting out support structures led to many problems on the final prototype of Handle Shield.

An issue that developed through the process of modeling was the limited resolution of 3D prints. The smallest possible whole a 3D printer could create is 0.5mm in a perfectly flat scenario; adding for error at such resolution we are looking at .85mm. Although, if the surface is upright and you would want to project a whole of that size, it would still be too small. This resolution was a problem when 2mm holes were needed on 2 walls that would then carry a roller with two exit pins that fit perfectly in the predicted hole of the wall. Although the design was meant to carry the rollers, it was not possible to print such holes due to the limited resolution of the 3D printer, especially in the upright position. As a solution, two holes were measured and drilled into place. Accounting for human error and machine error, the roller was unaligned on both ends, creating an uneven surface from which the film was to be pulled.

Injection molding would have not only given our prototype a greater edge on design flexibility, but it would have provided a uniform infill density throughout the entire model, in addition to a more uniform surface.

10.2. Protectant Film

The plastic film being dispensed is sticky in nature, which is a positive factor in most cases when it comes to contact but in the handle shield prototype it performed poorly. Due to the surface condition of the plastic film, it began to roll and stick on the lower roller which was designed to guide the plastic into the Waste Cartridge, subjecting the motor to resistance until it stopped.

This material flaw could easily be corrected if the material of the plastic film is changed to a slicker material allowing more slippage.

10.3. Roller Material

The type of plastic used for the rollers caused no issues in the final prototype of Handle Shield, but that will change immediately after the material for the plastic film is changed to a slicker plastic allowing for more slippage. To counteract the less grip factor between the surfaces, after the features of the plastic film are changed, a silicon like roller or a silicon surface for the existing rollers would have to be adapted.

11. Acknowledgements

The project was more challenging than it was imagined. The authors would like to thank Dr. Amir for guiding them throughout the project, Dr. Rahemi for showing them ways to improve their analysis, and Alaric for helping them with the 3D printing. Thank you everyone.

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13. Authorization & Disclaimer

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Assistive Partial Limb Exoskeleton (APLE)

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Abstract

The objective of this project is to develop a partial exoskeleton using non-invasive sensors and motors to facilitate enhanced musculoskeletal function of the lower and upper forearm. The way to achieve it is by using a digital servo motor located at the elbow joint of the arm, as well as a combination of surface electromyography (EMG) and linear displacement and rotational sensors. The target consumer of this product would be hospitals to treat patients that suffer from injuries and diseases such as spinal cord injuries (SCI) or ALS, also known as Lou Gehrig's disease. As the sensors detect electrical signals to the muscles of a patient the motor would assist in extending and contracting the arm. The use of linear displacement sensors would aid in monitoring the range of the movement and regulate the movement of the motor, as not to overextend the patient's axis of rotation. Developing a partial exoskeleton not only simplifies the construction and reduces the price, but it also acts as a framework for independently functioning limbs. Rather than using a full body harness, one can use the partial exoskeleton to help the body to do physical exercises.

1. Introduction

The target consumer of this product would be hospitals who treat patients that suffer from injuries and diseases such as spinal cord injuries (SCI) or Lou Gehrig's disease, also known as ALS. In the year 2019 there were approximately 249,000 to 363,000 people in the USA living with SCIs, and an average of 17,730 new spinal cord injuries each year [1]. Given the permanence and often damaging effects of these conditions, forms of physical therapy and rehabilitation are limited. This produces a need for a targeted, universally usable, and adaptable assistive technology that can help these patients regardless of what stage their disability is. Developing a partial exoskeleton not only simplifies the construction and reduces the total cost, but it also acts as a framework for independently functioning limbs. Rather than using a full body harness, one can use a partial exoskeleton to target sections of the body that need physical assistance. It would also decrease the total weight while increase the ease of use for the patients while operating.

The objective of this project is to develop a partial exoskeleton for the upper and lower forearm. This noninvasive device will be controlled by a combination of active and passive systems driven by a combination of surface electromyography sensors (sEMG), digital servo motors, and force sensors.

1.3. Background Research

1.3.1 Rehabilitation Options and Physical Therapy

Current medical practices for treating patients with ALS and SCIs can range from prescribed exercise regimens for posture control and the use of adaptive equipment to aid patients in their stability and movement. Trained physical therapists can assist their patients with working out unused or degrading muscles to keep them healthy and active. They can also teach those afflicted persons how to perform daily actions and activities with adaptive equipment, even when they are suffering from the condition [2]. Similar methods are used for those afflicted with spinal cord injuries; standard physical therapy can also help alleviate the reduced range of motion (ROM) and prevent pressure ulcers [3]. However, while physical therapy can help to retain muscle strength and flexibility for a time, there are still a number of limiting factors. Weekly exercise regimens are performed by trained physical therapists, yet not every patient can receive 24/7 support at home. The current equipment used to aid mobility and motor functions such as walkers, canes, and wheelchairs/power chairs are useful, but restricted in terms of promoting muscle exercise and restoring ROM [4]. Customized braces, also known as orthoses, are used to support parts of the body that either need positional correction, or stabilization due to loss of muscle strength or pain (Figure 1). Orthosis can be applied to patients who suffer from both ALS and SCIs. They are commonly used in locations such as the neck, arm, wrist and hands, or legs and ankles to save the patient's energy, while preventing further discomfort [5]. However standard orthoses lack the ability to return ROM to the patient, rather they focus on supporting degrading areas while relying on remaining functioning muscles to do tasks.

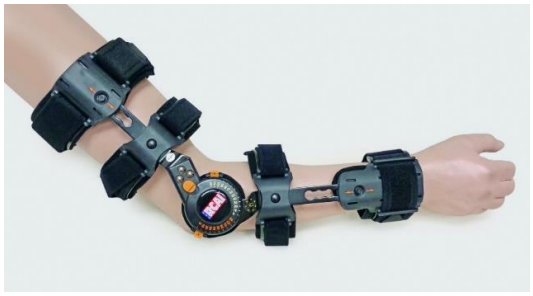


Figure 1: Forearm and Elbow Orthosis

1.3.2 Servo Motors and Angular Movements

To accomplish the multi-joint mechanical requirements of this technology, a series of servo motors located at the primary joints of the arm is planned. These servo motors would be powered by an external battery located within the upper arm frame and assist in the operator's flexion and extension of the wrist, elbow, and shoulder. Unlike other motors such as brushed or brushless that continuously rotate, servos rotate within a limited angle [6] and give more accuracy and control when managing the flexion and extension (Figure 2) of the exoskeleton. Flexion is the rotational motion that brings two adjoining long bones closer to each other. Extension refers to rotation in the opposite direction of flexion. This is to assist in the angular movement of synovial joints, the joints that allow considerable motion of the articulating bones such as the elbow, shoulder, and knee [7]. The average range of motion (ROM) for the human forearm during flexion and extension is from 0°–150° [8]. Therefore, servo motors would be

more beneficial for controlling the degrees of motion from the elbow joint, as to prevent the risk of hyperextension, strain and injury.

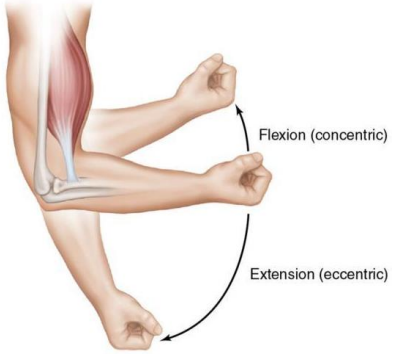


Figure 2: Flexion and Extension Diagram

1.3.3 Electromyography Sensor and Arduino Digital Board

The electrodes are placed onto the surface of the skin, located between the innervation zone of both tendons (Figure 3) , and relay electrical activity to the sEMG sensors via detecting muscle movement/contraction. This data is displayed in the form of waves which can be analyzed on the monitor of an oscilloscope (Figure 4) as well as an Arduino Serial Plotter [9].

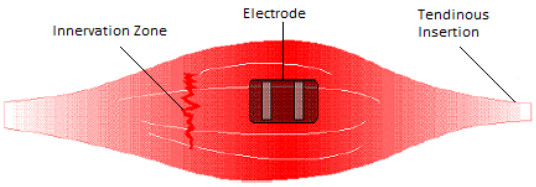


Figure 3: Innervation Zone of Muscle

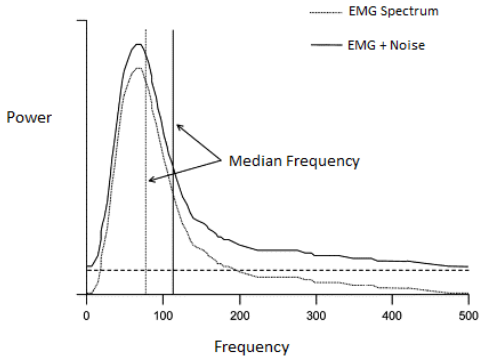


Figure 4: EMG Spectrum and Noise Influence

To control the output and direction of these motors the use of sEMG sensors, EMG detector, electrodes, and an integrated angle sensor within the digital servo motor will be applied to APLE. Arduino boards are a brand of open-source electronics platform used for a variety of industrial projects and prototyping. It is an inexpensive software and microcontroller platform that can connect to various peripherals and hardware. The model of microcontroller used will be the Arduino Uno R3. The Arduino software programming language is based on C/C++ and can be expanded through C++ libraries. This will allow clear and fast communication between the sEMG sensors and the other electronics on the exoskeleton, in turn improving the physical response time of the device for the user. The implementation of load cell force sensors within the device is to measure the interaction force between the exoskeleton and the user [13], recording and converting the physical force into an electrical signal that can be transferred to the microcontroller. This is accomplished through strain gauges located across the sensor, that measure changes in forces, which causes a change in their electric resistance [14].

1.4 Societal Impacts

- Social Impacts
    - Restored ROM and sense of normalcy for afflicted patients.
    - Increased health and reduced risk of muscle atrophy and further injury.
- Economic Impacts
    - Cheaper alternative to standard exoskeletal orthosis options.
    - Increased availability for patients within the rehabilitation market.
- Environmental Impacts
    - Non-toxic recyclable materials that can be repaired or replaced.

2. Requirements and Constraints

2.1. Marketing Requirements

Safety: The device must operate without causing discomfort or harm through overextension and must be compact and transportable. The device must have accurate movement and swift response time. The user must have control over the device's movement and intensity. Users should not require extensive training to operate or calibrate the device. The device should be offered at a comparatively low price to appeal to hospitals, rehabilitation centers, and individual consumers.

2.2. Engineering Constraints

For the APLE robotic orthosis, the digital servo's range of motion (ROM) must never exceed above 150° or under 0° of motion. The load capacity of the object lifted cannot exceed 20lbs. The cost of the machine should be reasonable for a consumer or small rehabilitation center to purchase. The device must not cause any strain or injury to the consumer through hyper extension or rapid movement. The device must be constructed of non-toxic recyclable materials in the event of damage or wear over time.

2.3. Engineering Standards

- Programming Language (ANSI 9521)
  The device should be programmed in the Arduino programming environment. The Arduino Uno can also be programmed in C++. The program should be straightforward and easy to comprehend as to make modifications if needed.
- Communications (IEC TR CD 60601-4-1)
  The device should have a number of settings that the operator can choose and adjust depending on how much assistive strength is needed. The user should easily comprehend what the settings are and which one to choose for each condition. The device should also employ a degree of autonomy in the active system.
- Electrical Devices (IEC/FDIS 80601-2-78)
  The device should work accurately and fast in synchronization with the sensors and electrical devices of the exoskeleton, promoting precision and safety for the user, while preventing malfunction or physical harm.

3. Hardware Design

3.1. CAD Orthosis Design

The robotic orthosis needs to facilitate both the control system as well as the mechanical system on a single device. The exoskeletal chassis can be broken up into six primary components during manufacturing: the upper arm segment, upper arm case, servo motor adapter, lower arm interface, lower arm segment/cuff, and upper arm cuff. The upper arm segment and upper arm case house the microcontroller, breadboard, connection wires, and two upper arm cuffs. The servo motor adapter holds the digital servo motor and angles it downward above the elbow joint. The lower arm interface connects the round gear of the motor and the back end of the load sensor to the forearm brace. The lower arm segment/cuff holds the front end of the load sensor as well as the wrist cuff. The 3D CAD software eMachineShop was used to design these parts and convert them to STL files for FDM 3D printing using a 0.6mm printer nozzle. The materials used for early testing and fitting was PETG filament for the upper arm segment, servo motor adapter, and upper arm cuffs; resin was used for the lower arm interface and lower arm segment/cuff, and PLA filament was used for the upper arm case.

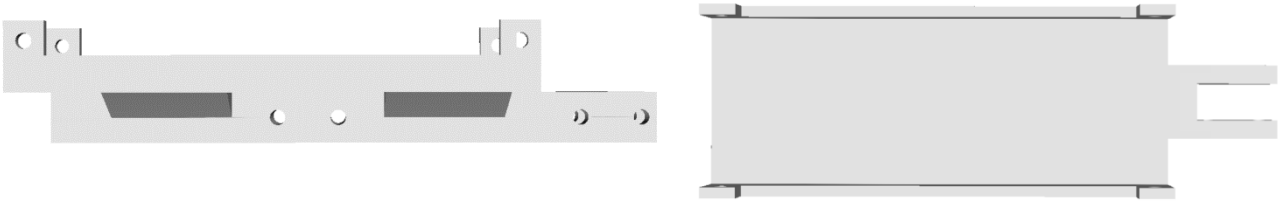


Figure 5:. Front & Top View of Upper Segment

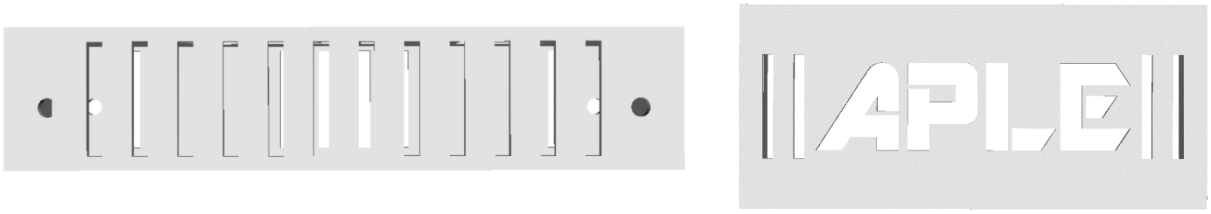
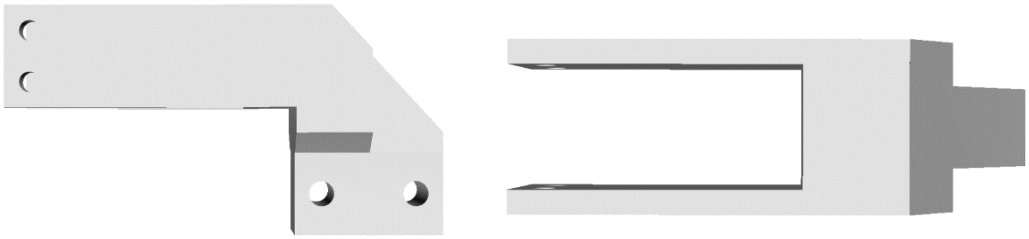


Figure 6: Front & Top View of Upper Case



igure 7:. Front & Top View of Servo Motor

Adapter

Figure 8: Front & Top View of Lower Arm Interface

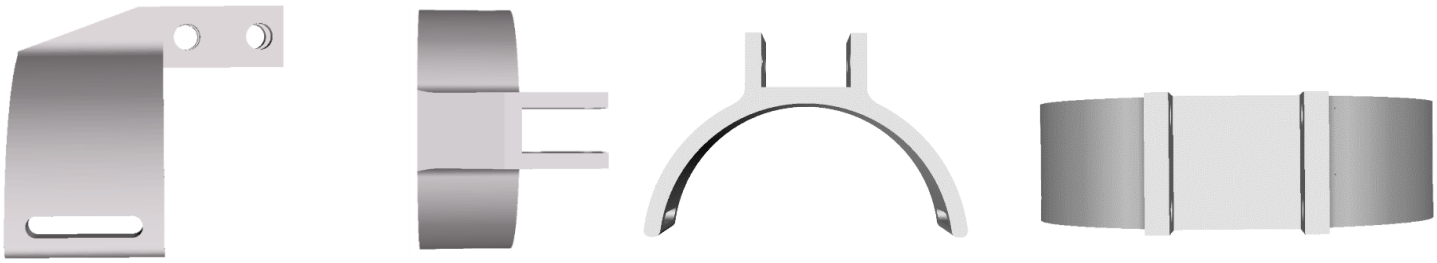


Figure 9: Front & Top View of Lower & Upper Arm Cuffs

3.2. Digital Servo Motor Modification and Force Sensor Wire Extension

When working with the first EduExo prototype kit the servo motor came with a custom pre-installed analog feedback wire. However the torque provided was insufficient in meeting engineering standards. For the APLE project, the component was upgraded to a 25kg digital servo motor for the elbow joint. Since it did not come from the factory with an analog feedback wire it would not send the positional angle sensor signals to the Arduino board. Therefore a fourth orange analog feedback wire was soldered onto the circuit board of the motor underneath the top cover. The range of motion for the digital servo motor is 270° but will be capped to a range of 0°–150° with the Virtual Wall Control code. This means that the robotic orthosis can be recalibrated for ambidextrous use on both arms, by adjusting the range of allowable motion.

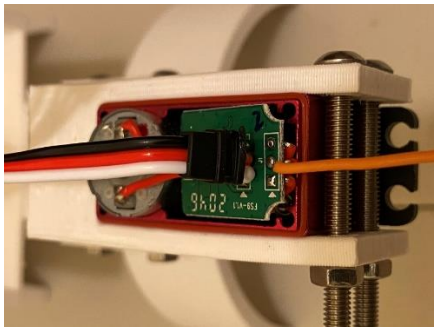


Figure 10: Analog Feedback Wire in Digital Servo Motor

The force sensor's wires connected to the strain gauge needed to be extended and reinforced due to their thin diameter. By soldering an extension wire to the tip, along with reinforcing it with two layers of heat shrink tubing, the force sensor successfully relayed stable force voltage signals to the bread board and Arduino Uno.

3.3. Arduino & Breadboard Configuration

The Arduino Uno and the breadboard work in unison to collect and interpret the signals coming from both the digital servo motor and the force sensor. The strain gauge wires of the force sensor connect to the breadboard and the INA125 amplifier chip, while a voltage wire and analog wire are connected to the Arduino Uno. Likewise the servo motor and EMG detector connections are connected to the Arduino as well.

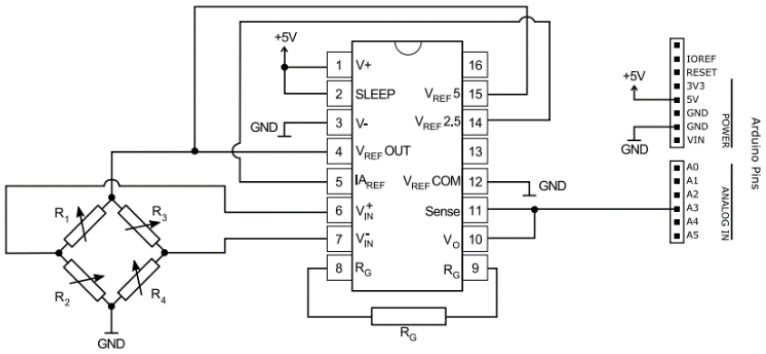


Figure 11: Schematics of Connections between Force Sensor, Amplifier Chip and Arduino

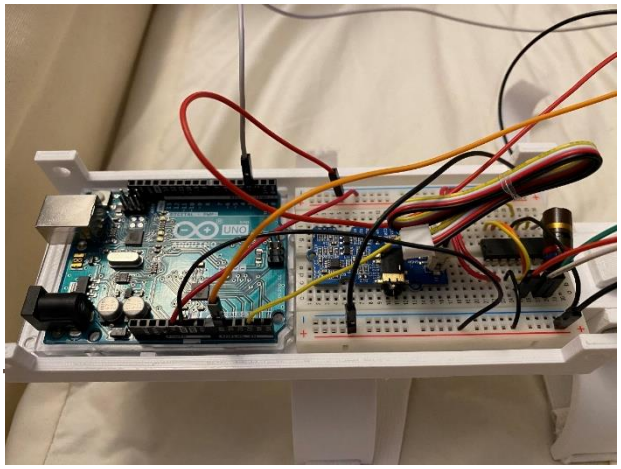


Figure 12: Final Circuit Configuration with Arduino Uno & Breadboard

3.5. Mathematical Formulation

The primary focus of this section's discussion shall be the torque produced by the device in relation to the elbow joint and muscles of the forearm. The forces behind the musculoskeletal system of the arm and its interaction with the servo motor attached near the joint will be rotational force. As shown in (Figure 12) there are many muscles that work together to generate elbow movement, and in turn generate torque [14].

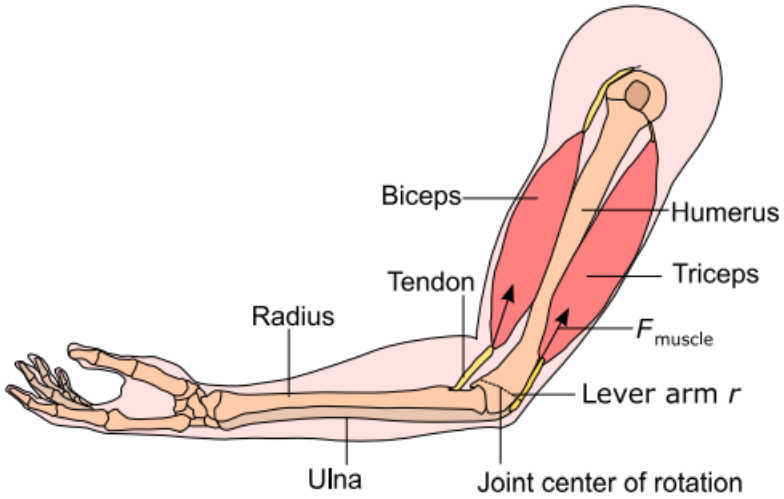


Figure 13: Human Elbow Joint and Major Muscles

The formula for muscle torque, letters and subscripts used is as follows:

$$\boldsymbol{T_{muscle} = F_{muscle} \cdot r} \qquad (1.1)$$

Where T_{muscle}:= Torque of the muscle, F_{muscle}: = Force of the muscle, r: = Lever arm

The torque generated by the exoskeleton comes from the servo motor actuator, which is transferred through interaction forces across the brace. This in turn reduces the loads on the human muscles. Since the actuator is aligned with the joint center of rotation, the exoskeleton torque combines with the muscle torque for the total torque at the joint.

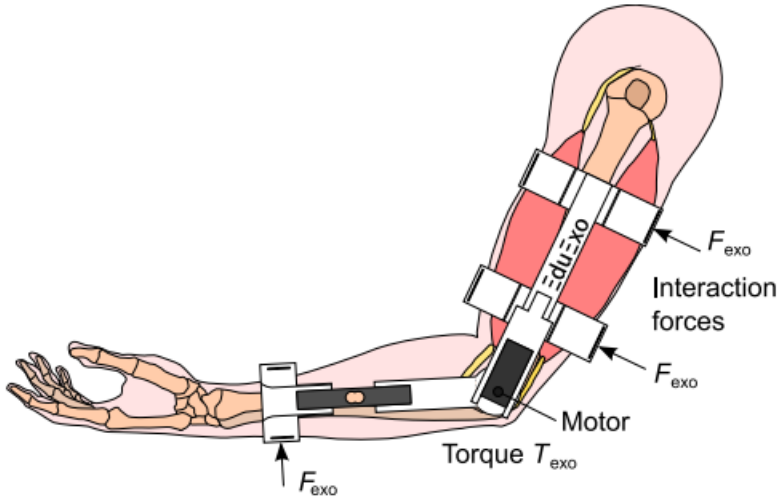


Figure 14: Exoskeleton Attached to Arm & Contact Forces

The formula for exoskeletal torque, letters and subscripts used is as follows:

$$\boldsymbol{T_{exo} = F_{exo} \cdot r} \qquad (1.2)$$

Where T_{exo}: =Torque of the exoskeleton, F_{exo}: = Force of the exoskeleton, r: Lever arm

The formula for joint torque, letters and subscripts used is as follows:

$$\boldsymbol{T_{joint} = T_{muscle} + T_{exo}} \qquad (1.3)$$

Where T_{joint}: =Torque of the joint, T_{muscle}: = Torque of the muscle, T_{exo}:= Torque of the exoskeleton

The formula for expressing the joint angle (φ) elbow (in degrees) as a function of the digitized sensor value is as follows:

$$\varphi_{elbow} = \frac{90° - 0°}{a_{90} - a_0} \cdot (pos_{is} - a_0)$$

Where φ_{elbow}: =Angle of the elbow joint, a_x: = Sensor value, pos_{is}: = Position value

The formula for finding the percentage change in body weight of a segment of the human body is as follows:

$$S_P * \frac{T_W}{100} = S_w$$

Where S_P: = Body Segment Weight Percentage, T_W: = Total Body Weight, S_W: = Body Segment Weight

4. Software Design

4.1.1 APLE Gait Restoration Control System

In the process of restoring and maintaining a patient's ROM, we have to apply methods for rehabilitative exercise and gait modification within their routine. Gait modifications are typically used in the rehabilitation of musculoskeletal conditions such as osteoarthritis and patellofemoral pain syndrome, yet they can be applied to other forms of musculoskeletal physiotherapy [15]. The basic routine used within this program is a simple joint flexing and muscle stretching exercise. APLE autonomously assists in flexing and extending the patient's forearm in repetition to strengthen the biceps and triceps brachii primary muscles as well as excite nerve activity [16]. It uses point-to-point movement positional control to move the exoskeleton in a flexion motion between two points: Flex counter-clockwise from 0°-150° and extend back to its resting position. This will continue for 5 reps each sequence (number of reps adjustable within the code), which can be initiated by a button on the Arduino microcontroller or directly from a connected laptop running the code. For each rep, two load sensor and position sensor calibrations will run between both points of the set motor angle ROM, displaying the load value that APLE is experiencing during flexion and extension, as well as the adjusted position value to show for deviation while lifting the patient's arm and external loads.

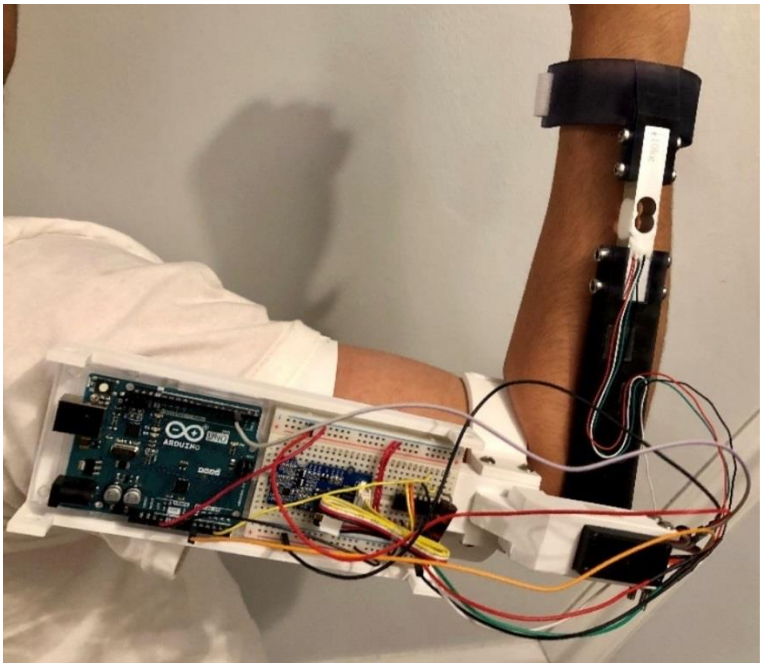


Figure 15: APLE Robotic Orthosis Complete Construction

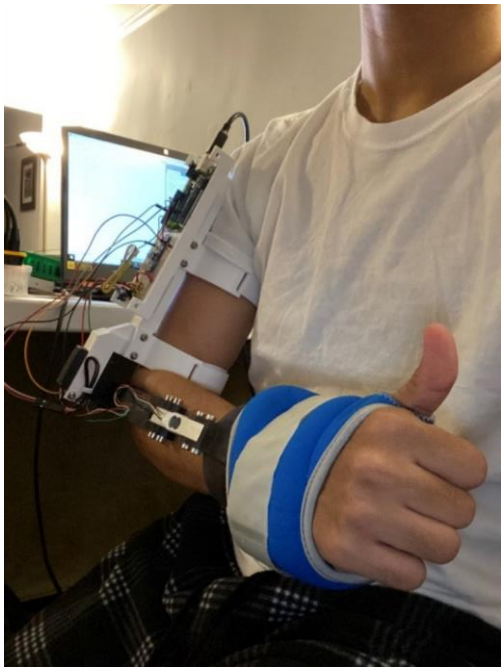


Figure 16: Gait Exercise Routine with Wrist Weight

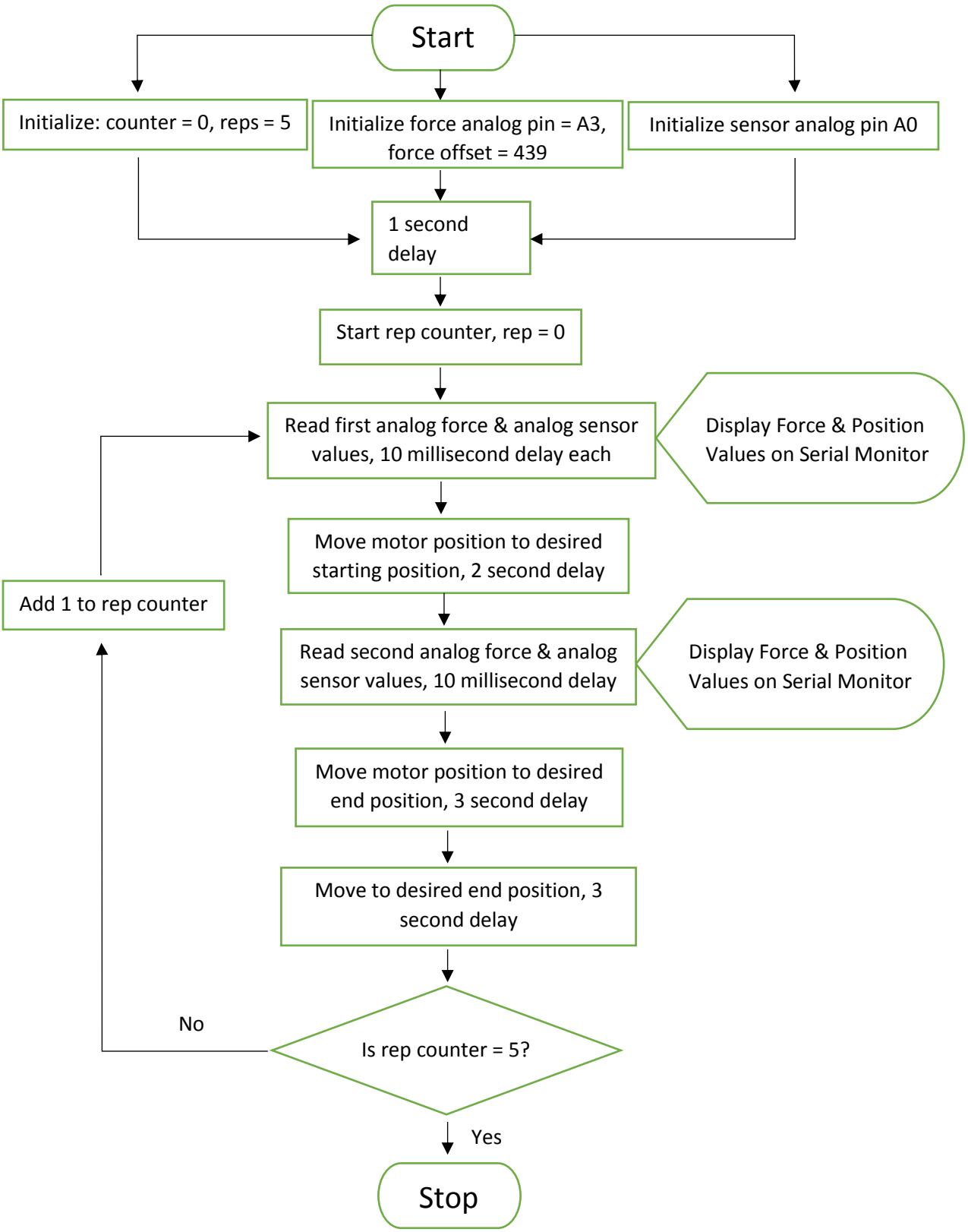


Figure 14: APLE Gait Exercise Control System

5. Testing

5.1. APLE Gait Exercise Testing

For this experiment, the APLE robotic orthosis was worn on a male patient to rehearse Gait exercises. Three trials were conducted, each with five total reps the patient had to perform with the exoskeleton. According to Plagenhoef, S., Evans, F.G. and Abdelnour, T.'s 1983 study "*Anatomical data for analyzing human motion*", the mean segment weight of the forearm for a male is approximately 1.87% of their body weight [17]. Given the patient has a body weight of 135lbs, the approximate weight of the forearm would be 2.5lbs. The weight of the APLE lower segment components is approximately 0.5lbs, leading to a total initial weight of 3lbs. Each trial added more weight to the patient's hands at the end of the forearm. Measuring the force sensor's output values, the average resting value is 355 bits. An increase in bits means torsional force is applied clockwise and downward, while a decrease in bits means torsional force is applied counterclockwise and upwards. With this the average bit value per pound = 39 bits. For this particular exercise experiment, a rep is considered complete if it passes all of the following criteria:

- The recorded positions must shift fully between set motor angles.
- The recorded positions must not hyper extend past the first joint motor angle.
- The recorded positions must not stall or exceed past the second joint motor angle.
- The force sensor values must never exceed the maximum load of the hand.
- The force sensor values must shift from high value to low value.

If any of these criteria are not met, the rep is considered a failure. After consecutive testing it seems that it takes an average of two failed starting reps before the patient became comfortable with the rhythmic assistance of the APLE orthosis. Once adjusted, the force values remained stable, showing that the exoskeleton was bearing a majority of the torsional load.

Table 1: APLE Gait Exercise Initial Variable & Rep Table

Gait Trial	Load (lbs)	Set Motor Angle Range (°)	Load Type	Reps Completed
1	3	33.43 – 139.37	Forearm	5/5
2	5	33.43 – 139.37	Forearm + 2lb weight	3/5
3	7	33.43 – 139.37	Forearm + 4lb weight	3/5

Table 2: APLE Gait Exercise Trial Data Table

Gait Trial 1	Rep #	Recorded Positions (°)	Force Sensor Values (bits)	Rep Pass/Failed
	1	85.89 – 117.26	357 – 351	Passed
	2	52.97 – 147.09	389 – 330	Passed

	3	34.97 – 141.94	367 – 347	Passed
	4	42.69 – 177.43	363 – 354	Passed
	5	36.00 – 160.46	357 – 347	Passed
Gait Trial 2	Rep #	Recorded Positions (°)	Force Sensor Values (bits)	Rep Pass/Failed
	1	132.69 – 136.80	352 – 357	Failed
	2	132.17 – 206.23	354 – 321	Failed
	3	67.89 – 142.97	407 – 338	Passed
	4	60.69 – 137.83	407 – 354	Passed
	5	39.09 – 141.94	408 – 319	Passed
Gait Trial 3	Rep #	Recorded Positions (°)	Force Sensor Values (bits)	Rep Pass/Failed
	1	101.83 – 56.06	358 – 349	Failed
	2	137.83 – 145.54	353 – 326	Failed
	3	56.06 – 137.83	367 – 353	Passed
	4	37.03 – 138.4	368 – 353	Passed
	5	36.00 – 136.80	360 – 356	Passed

6. Project Management

Table 3: Estimated Work Breakdown Structure

Work Breakdown Schedule (WBS)	Duration	Start	Finish
Project 1. Assistive Partial Limb Exoskeleton (APLE) Design	113 days	1/19/2020	5/11/2021
Project 2. Design First Prototype	31 days	1/9/2021	2/9/2021
Task 1. Order Prototype Hardware	7 day	1/18/2021	1/25/2021
Task 2. Design Prototype Chassis	13 day	1/15/2021	1/28/2021
Task 3. 3-D Print Prototype Chassis	1 day	1/15/2021	1/16/2021
Task 4. Assemble Prototype Chassis	3 days	2/4/2021	2/7/2021
Task 4.1 Download Software	1 day	1/30/2021	1/30/2021
Task 4.2 Connect Hardware/Software	7 days	1/31/2021	2/7/2021
Task 4.3 Develop Arduino Code	4 days	1/31/2021	2/3/2021
Task 4.4 Test Arduino Code	12 days	1/31/2021	2/12/2021
Task 4.5 Assemble Entire Prototype Exoskeleton	7 days	1/31/2021	2/7/2021
Task 4.6 Test First Prototype Exoskeleton	8 days	2/3/2021	2/14/2021
Project 3. Make Improvements to First Design	57 days	2/14/2021	4/11/2021
Task 1. Design Improved Prototype	12 days	2/14/2021	3/4/2021
Task 2. Research Improved Materials	7 days	2/14/2021	2/20/2021

Task 3. Additional Cost Analysis of Improved Hardware/Materials	6 days	2/15/2021	2/20/2021
Task 4. Order Improved Prototype Hardware	6 days	2/15/2021	2/20/2021
Task 5. CAD Design Improved Prototype Chassis	28 days	2/18/2021	3/18/2021
Task 6. Test Materials in Laboratory	7 days	3/19/2021	3/26/2021
Task 6.1 Tensile Testing	3 days	3/20/2021	3/22/2021
Task 6.2 Impact Testing	3 days	3/20/2021	3/22/2021
Task 6.3 Fatigue Testing Hardness Testing	4 days	3/24/2021	3/27/2021
Task 7. Order Improved Prototype Machined Chassis	3 days	3/29/2021	3/31/2021
Task 8. Assemble Improved Prototype Chassis	33 days	4/5/2021	5/7/2021
Task 8.1 Run Software	1 days	4/5/2021	4/5/2021
Task 8.2 Connect Hardware/Software	3 days	4/5/2021	4/7/2021
Task 8.3 Expand Existing Arduino Code	21 days	4/7/2021	4/28/2021
Task 8.4 Test Improved Arduino Code	31 days	4/7/2021	5/7/2021
Task 8.5 Assemble Final Prototype Exoskeleton	5 days	4/7/2021	4/11/2021
Task 8.6 Test Final Prototype Exoskeleton	26 days	4/11/2021	5/7/2021
Project 4. Compile Engineering Notebook	80 days	2/21/2021	5/10/2021
Task 1. List All Stages of Development	80 days	2/21/2021	5/10/2021
Task 1.1 List All Phases of Prototypes	76 days	2/21/2021	5/7/2021
Task 1.2 List All Iterations of Code	76 days	2/21/2021	5/7/2021
Task 1.3 List All Expenses	4 days	3/31/2021	4/3/2021
Project 5. Prepare Final Presentation	28 days	4/12/2021	5/10/2021
Task 1. PowerPoint Presentation	21 days	4/12/2021	5/3/2021
Project 6. Prepare Final Capstone Report	28 days	4/12/2021	5/10/2021
Task 1. Edit Pre-Capstone & Capstone Drafts	7 days	4/12/2021	4/19/2021
Task 2. Edit Project Management Proposal	7 days	4/19/2021	4/26/2021
Task 3. Combine Both Texts for Final Draft	7 days	4/26/2021	5/3/2021
Project 7. Present Capstone Degree Project	1 day	5/11/2021	5/12/2021
Task 1. Practice Live Demonstration	14 days	4/26/2021	5/10/2021
Task 2. Live Demonstration of APLE Device	1 day	5/11/2021	5/12/2021
Task 3. Prepare Potential Questions About Project	14 days	4/26/2021	5/10/2021

7. Conclusion

The APLE is a versatile and inventive platform within the realm of wearable robotics. Exoskeletal development, within the realm of medical rehabilitation, has come a long way from inception, yet it is still a relatively new technology. Like all technologies there will always be room to innovate and improve on existing designs, making wearable robotics more efficient and widespread within the market. Consumers will experience an intuitive, effective, non-invasive, financially available, and safe rehabilitation device when using the APLE system.

This design which implements non-invasive surface with EMG sensors and low-speed-high-torque servomotors will deliver industry standard performance in line with other robotic orthoses, filtering out excess EMG + noise in the EMG spectrum, to further isolate controlled

electric muscle impulse signals and to improve mechanical accuracy. The implementation of digital servo motors with integrated positional sensors combined with the Arduino Uno board will communicate information across all electronics to constantly monitor the patient's ROM and arm positioning. This invention also reduces the likelihood of hyperextension or sudden, uncomfortable increases to speed, while retaining power and structural support for the consumer. In future developments, this partial-limb design can be expanded to target not just upper limb rehabilitation, but also spinal adjustment and lower limb rehabilitation in various consumer cases. For these reasons, this work contributes to the future development of similar exoskeletal and wearable robotic systems within the medical field.

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Automatic Shopping Cart

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Abstract

The purpose of this engineering project is to help improve the shopping experience for seniors, physically disabled patrons, and parents while financially benefiting store owners. The idea is an automatic shopping cart that gives customers a hands-free shopping experience. The cart consists of an Arduino Uno microcontroller, a camera, as well as VEX parts and 3D printed components for the frame structure. The camera provides the environmental information to the microcontroller, so that it can control the cart safely and automatically follow the user with an effective distance of one feet. The developed product, with an affordable cost, is expected to largely improve the shopping experience, while increasing commerce for many establishments.

1. Introduction

The automatic shopping cart can help a wide range of people at the shopping mall. Many people need to keep an eye on their children when they are shopping. They can easily shop while not having to worry about whether to focus on moving the shopping cart, or the children. Further, autonomous cart is best for the elderly who may not have the strength or endurance to push the cart for the entire time. With the autonomous cart they can focus on the items they need to buy instead of getting tired of pushing the cart around.

By taking away the necessity to push the cart, people with physical disabilities may have an easier time when shopping. The cart will generally ease up the shopping process for people. By not having to worry about pushing the cart, consumers can focus better on the products available and move through the store easily.

The autonomous shopping cart will thus improve the shopping experience for different customers with different problems, whether they are parents, seniors, or physically disabled patrons. Customers can focus more on the products they are buying, because they no longer have to worry about pushing the shopping cart. This can increase the efficiency of shopping for the customers, and increase their overall mood about shopping as well.

2. Background Research

There are quite a few innovative shopping carts available that help to streamline the entire shopping experience, from browsing to checking out. Companies such as Amazon, Caper, Five Elements Robotics, and Robotnik have already worked on various automatic shopping carts that help to reduce shopping time, while simultaneously analyzing customer data. Amazon went as far as creating its own grocery store where people can use it's automatic shopping cart, the Dash Cart [6], which helps customers pay right from the shopping cart. Robotnik created a similar version for the popular grocery chain H-Mart in South Korea, the ELI [4]. This shopping cart is also made only for that specific store chain. Similar to the Dash *C*art, ELI also helps customers pay instantly and directs them to aisles.

The examples listed above are only for certain chain stores, meaning they can't be used in every store. According to the article "How Smart Shopping Carts Can Impact Retailers Throughout the US" [8] there was an 18% increase in the number of products purchased each time there is a smart shopping cart experience. The Caper [9] and DASH [5] shopping carts help the customers also pay instantly, while showcasing where certain products are located.

These shopping carts mainly focus on benefitting the stores and companies by making it easier to pay, which makes the shopping experience quicker, thus allowing for more customers. This Automatic Shopping Cart project, however, focuses on the customers first. Our aim is to ease the shopping experience for customers who might have mobility issues, or parents who need to watch their kids. Unlike the ELI, which is only meant for H-Mart stores, our robot can be used in any store to help store owners and customers.

Fig 1 & 2 from left to right: The ELI shopping cart; Amazon's Dash shopping cart

3. Objective

The objective of this project is to design and implement a load carrying robot that tracks a landmark that will be attached to a person in order to follow them. The first goal is to create a rolling chassis that moves autonomously. The next goal is to add a cart mechanism to hold a payload of 20 pounds and can accurately follow a landmark. Next, the robot will be improved to make turns so that it can better track and follow the landmark. Once the turning is complete, the robot will be programmed to go backwards if the landmark is too close to the robot to prevent crashing. After this goal is reached, a tilting mechanism for the camera will be made and tested. Final adjustments will help to control the distance between the person and robot and speed of 0.37m/s (1.2ft/s)to maintain a 1ft gap between the robot and person.

4.1 Marketing Requirements

In order to appeal to stores and customers, the automatic shopping cart should meet the following marketing requirements:

1. Affordability: The shopping cart should be inexpensive for store owners
2. Safety: The cart should have effective automatic maneuverability to not crash into objects or people.
3. User-Friendly: The robot should be easy to use since the target audience range is broad.
4. Longevity: The cart should have a decent battery life to last an average shopping time of around 40 minutes.
5. Robust: The robot should be strong enough to carry groceries for users.

4.2 Engineering requirements

Mechanical Components

1. Chassis/frame
   Dimension: 15” x 15”
   Materials: Bumpers, rails, #8-32 keps nuts and #8-32 x 1/4" locking star drive screws
2. Drive
   Method: Rear wheel drive (RWD)
   Materials: 4” Traction wheels, 4” omni wheels, 18T sprockets and chain links
3. Container
   Dimension: 11” x 13” x 13”
   Material: Plastic (Storage container) & lexan
4. Compartment for electronics
   Dimension: 2” x 7” x 3”
   Material: Plastic (3D printed)
5. Camera holder
   Dimension: 6”x6”x6”
   Material: Lexan

4.3 Electrical Requirements

4.3.1 Motors

The required specifications for the motors are as follows:

- Rotational Speed: 71 rpm
- Torque: 0.184 Nm.
- Max current(under load): 0.5A
- Usage on Battery Pack: 1.05mAh*

The motor that will be used for this project is the VEX 393 motor. The motor has a rotational speed of 100 rpm, and a torque of 1.67 Nm. The motor has a free current of .37 A, and the max stall current is 4.8 A. The total weight of the motor is .0192 lb.

4.3.2 Motor Controller

A motor controller controls the motor's various functionalities, such as, starting and stopping the motor, directional control, regulating and setting the speed and regulating or limiting the torque. Motor controllers also protect against overloads and electrical failures.

For the motor controller in our project we have chosen the vex motor controller 29. The motor controller 29 regulates the speed of a vex motor based on a signal it receives from a VEX Microcontroller. This allows for control of the vex motor 393, which we are using, and doesn't have a built-in motor controller.

The motor controller will be connected directly to each motor and the motor controller will then be connected to the Arduino UNO R3 via a breadboard to transfer proper connection points for the microcontroller.

4.3.3 Battery

The choice of battery for this design is very important, because of the somewhat long operating time, since most shoppers take around 40 minutes to get in and out of the grocery store on average. We have done calculations for the battery to last around three times longer than needed to ensure that even on two separate lengthy shopping trips the battery will still have enough power for store associates to recharge the cart.

Listed below are the steps taken for battery selection:

- Listing out the components and their specific current consumption.
- Add total value of current consumption and the time duration for which cart is to run
- Apply Formula to calculate total battery supply in $\boldsymbol{m}$Ah
- Time(h) = Total Battery Supply($\boldsymbol{m}$Ah) /Total Current Consumption($\boldsymbol{m}$A)
- For cart usages:
    - 1 x Ultrasonic Sensor: 15$\boldsymbol{m}$A
    - 2 x DC Motor: 800$\boldsymbol{m}$A
    - 1 x Pixy2 Camera: 140$\boldsymbol{m}$A
    - Total Battery Supply($\boldsymbol{m}$Ah) = 1755$\boldsymbol{m}$Ah

After calculating all electrical components' total current consumption mAh(mili-amps per hour) and time needed for use we made a choice in battery based on the necessary mAh for the total battery supply. A battery with 5200mAh will satisfy our needs.

4.3.4 Camera

After researching multiple methods for following users, it was decided that using a camera for image tracking is the most feasible method. Other methods such as LiDAR and signal tracing are too expensive or don't meet our distance requirement. The camera that will be used in our project is the Pixy2 by Pixy. Pixy is a company that first started in the CREATE Lab at the Robotics Institute of Carnegie Mellon University. Eventually, the company worked with CharmedLabs to create the Pixy2 specifically for arduino, raspberrypi, LEGOmindstorms, and other controllers for hobbyists and projects.

The main issue with using a camera and an arduino is the processing power. Initially, we were faced with the issue of the arduino not having enough RAM and memory to handle both tracking

and movement of the robot. This is why the Pixy2 stands out from other cameras available in the market. The camera has an internal image processor, is trainable, capable of color based tracking, has 60 frames per second (fps), and is an open source software which makes codes available for everyone.

4.3.5 Microcontroller

Just as a CPU is the brain of a computer, our microcontroller works as the brain of our cart. It collects information from input devices and then executes programs, and according to this execution, it controls the output devices such as motors and LEDs.

In our project we will be using the Arduino Uno R3. The arduino is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). Programs can be loaded onto it from the Arduino computer program.

We will be operating all of the electrical components with the arduino uno r3, determining proper output voltages and control for the motors via the motor controllers connected to the arduino. We will read and analyze the data retrieved from the pixycam, properly distributing the power of the battery for all electrical components as needed. Under maximum load, the Arduino UNO R3 will be able to power both motors and all other electrical components.

4.3.6 Servo Motor

A servo sotor is a little gadget with a yield shaft. This shaft can be situated for precise situations by conveying the servo a coded signal. However long the coded signal exists on the input line, the servo will keep up the precise situation of the shaft. Servos have integrated gears and a shaft that can be accurately controlled. Standard servos permit the shaft to be situated at different points, normally somewhere in the range of 0 and 180 degrees.

For application in our cart, the servo motor will be functioning as our tilt mechanism. This will allow for the PixyCam to track the selected object even if there is a height change with each of the customers. The servo will be connected directly into the PixyCam for power and signal, determining the angle in which the PixyCam should be directed to accurately track a customer.

4.3.7 PCB Protoshield

The Arduino Prototyping Shield makes it easy to design custom circuits. I was able to solder parts to the prototyping area to create the wiring design for the project. It was also used in early tests before I applied soldered connections, I was able to use it with a small solderless breadboard to quickly test circuit ideas without having to solder. It's got extra connections for all of the Arduino I/O pins, and it's got space to mount through-hole and surface mount integrated circuits. It was a convenient way to make my custom circuit and Arduino into a single module and conserve space for the electrical components' hard wiring.

4.4 Engineering Standards

The American National Standards Institute (ANSI) requires a close regulation for mobile consumer products that contain electrical components [1] to avoid accidents that can potentially be caused by electricity. In order to meet this standard, a closed compartment is designed for the electronic components which will run the shopping cart.

Additionally, the American Society for Testing and Materials (ASTM) has specific weight requirements for shopping carts that are intended to cover children under the code ASTM F2372-11a [2]. However, the prototype is not intended to carry children.

Moreover, in the process of creating the parts and building of the prototype, CATIA and VEX standards will be used as well as IEEE (Institute of Electrical and Electronics Engineers) electrical safety standards (Current Level & Probable Effect on Human Body) for suggested standard use of motor, sensors and connectivity of the mobile prototype.

For this project, the Arduino IDE was used to implement the programming aspect. The IDE uses the C/C++ language, and the International Organization for Standards (ISO) was used for the structural integrity of the code. These standards help to make the writing and understanding of the code easy to follow, so it can be adjusted by anyone.

5.1 Shopping Cart Design

The prototype's chassis is 15"x15" in dimension, and it is built using the standard VEX bumpers, rails and angles. The materials are made of cold rolled steel per ASTM A-1008 CS Type B, and have tensile strength of 40ksi (275MPa) [10],[12]. The carrier is raised 12.5" from the ground, using a VEX standard C-channel (see figure 3) with the same properties as mentioned earlier. For the carrier, a base of a 13"x13" milkcrate made of plastic is used, and to reduce the excess weight, the walls of the crate have been removed and replaced by lexan sheets, as shown in fig 4.

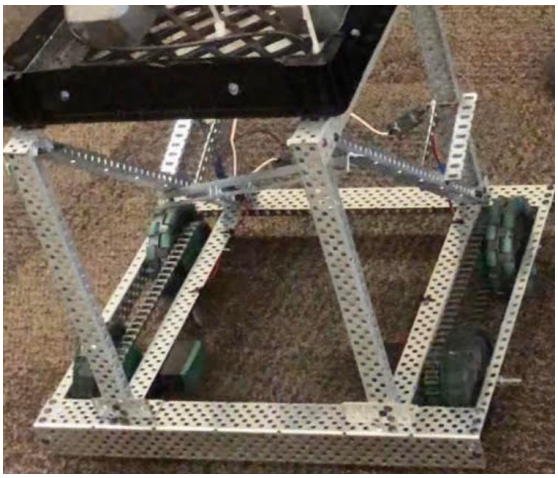

Figure 3: Columns of the carrier

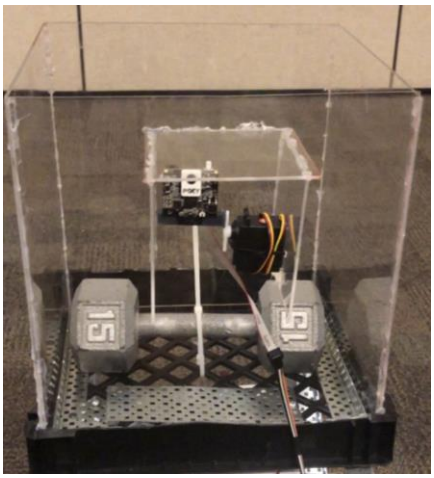

Figure 4: Carrier's walls and base

5.2 Internal Structure Analysis

There is one beam on either side of the base of the carrier which carries the load. The maximum allowable load is 15lb (67N). Since the cart is symmetrical, the load placed in the middle of the carrier is equally distributed on either side and analyzed [11].

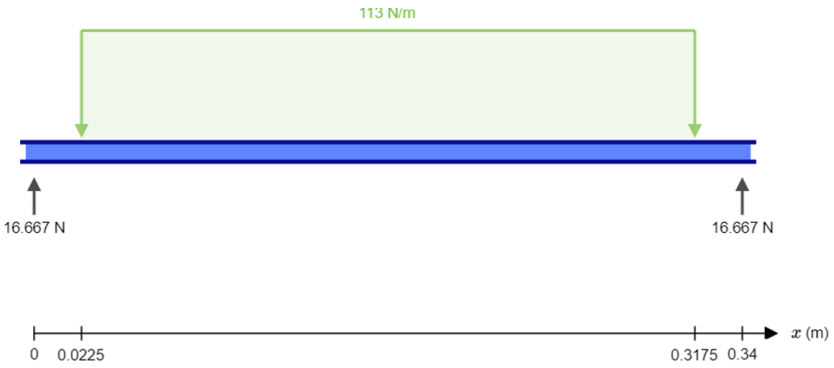

Figure 5: Beam analysis

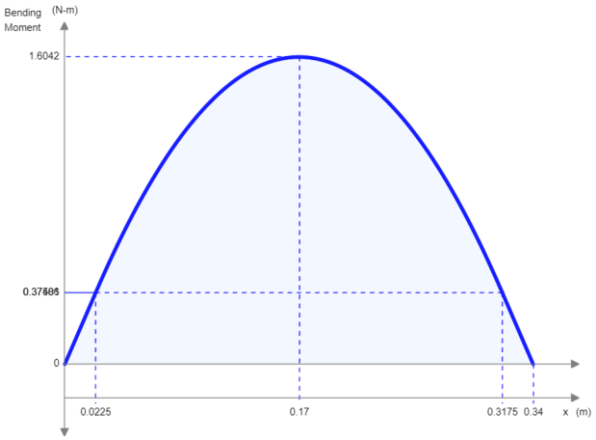

Figure 6: Moment diagram

Beam Analysis

The cross-section of the L-beam shown below in figure 7 has holes as shown in figure 8. Taking the holes into consideration, the material properties are calculated below.

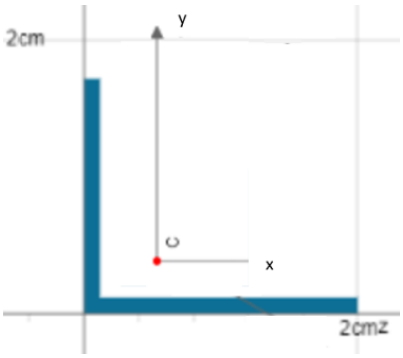

Figure 7: Cross-section of L-beam holes

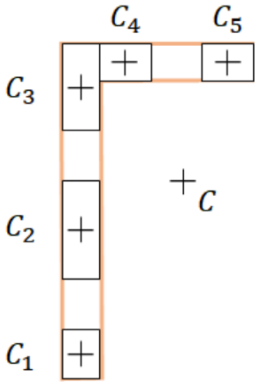

Figure 8: Cross-section of the L-beam with

Area: $4.212 \times 10^{-5}\ m^2$ (1)

C: 0.0044m (2)

I: $1.7 \times 10^{-9} m^4$ (3)

Load placed in the crate: 66.9N (4)

Load distributed on either side of the supported crate due to the symmetry: $\frac{66.9N/2}{0.295m} = 113N/m$ (5)

Maximum moment: 1.6 Nm (6)

$$\sigma \text{ max} = \frac{Mmax * C}{I} = \frac{1.6Nm * 0.0044m}{1.7x10^{-9}m^4} = 4.14 \text{ MPa} \quad (7)$$

Ultimate strength = 275MPa x 80% (considering the holes) = 220MPa (8)

$$\text{F.S (beam alone): } \frac{Ultimate\ strength}{Maximum\ \sigma} = \frac{240MPa}{4.14MPa} >> 2 \quad (9)$$

Column Analysis

The cross-section of the C-channel shown below in figure 9 has holes similar to the L-beam above. Taking the holes into consideration, the material properties are calculated below.

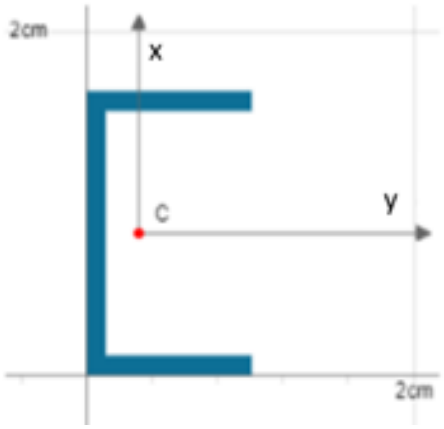

Figure 9: Cross-section of the C-channel

Critical loading (Fixed and pinned)

Column: C-channel (10)

Length: 0.3175m (11)

Area: $4x10^{-5}m$ (12)

Load on one column: $\frac{67N}{4} = 16.75N$ (13)

$\sigma = \frac{167.5N}{4x10^{-5}m} = 419Kpa$ (14)

E: 200 GPa x 80% = 160GPa (holes into consideration) (15)

Effective Lengthyz: 0.7L = 0.7 (0.3175m) = 0.22m (16)

Effective Lengthxz: 0.7L = 0.7 (0.3175m) = 0.22m (17)

Ix: $4x10^{-10}m^4$ (18)

Iy: $1.7 \times 10^{-9}\ m^4$ (19)

Pcritical xz: $\frac{\pi^2 EIx}{Le^2} = 13.1KN$ (20)

Pcritical yz: $\frac{\pi^2 EIy}{Le^2} = 55.4KN$ (21)

$FS = \frac{Ultimate\ load}{Allowable\ load} = \frac{13.1KN}{16.75N} >> 2$ (22)

Though this is prototype, the internal structure is well built to carry a 15lb load, with a factor of safety that is more than 2, and if this project were to be reiterated in a final design, a design with a factor of safety that is more than 6 should be taken into consideration, since it is a dynamic system.

Dynamic Analysis

The desired velocity the prototype is set to travel at is 0.37m/s (1.2ft/s), and the maximum acceleration set for the motion is $0.3m/s^2$ so that tipping can be prevented, especially upon braking while going backwards. Additionally, the control team performed experiments to increase the time taken to come to a full stop while going backwards, in order to reduce the consequences of harsh stops.

5.3 Compartment

To keep the electronics in one place and to minimize the user's interaction with it, a compartment portion is 3D printed (see fig 10) and mounted under the carrier as shown in fig11. This product also follows the American National Standards Institute (ANSI) safety standard which requires a close regulation for mobile consumer products that contain electrical components to avoid accidents that can potentially be caused by electricity.

Figure 10: 3D printed compartment

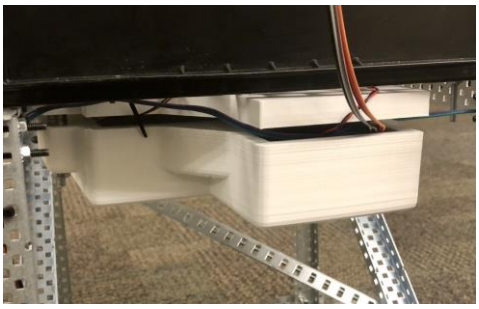

Figure 11: Compartment under the carrier

5.4 Camera Holder

Since this prototype uses a camera which works the best with a tilt function, after experimenting with various designs and 3D printed holders, the most effective and the lightest holder for the servo motor and the pixy camera is built using lexan. A 1.75" long shaft was 3D printed and attached to the servo motor and the whole structure is later mounted on the face of the front wall with the use of lexan while enabling the pixy camera to tilt without any distractions (see fig 12)

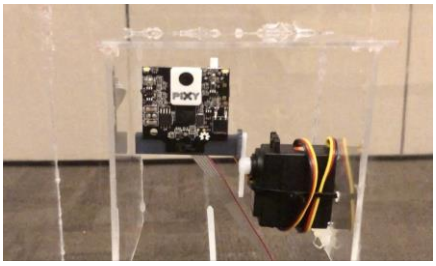

Figure 12: Camera and servo holder

5.5 Drivetrain

The drive train for the robot is a rear wheel drive, which is known to be better for carrying heavy loads than front wheel drive, and all wheel drive. Since the automatic robot would only need to track users at a controlled speed on floors that are generally flat and dry like the ones in (grocery) stores, it did not demand any complex drive mechanism. As a result, the team decided to go with rear wheel drive using two 4" traction wheels powered by motors in the back and two free 4" omni wheels in the front connected by chain links. The traction wheels are specifically used in the rear to provide enough traction, even while going over mats that can be found in some stores, and the omni wheels are used in the front which makes turning effortless.

For this project, the drive motor sizing tool was used to select the motor. According to the engineering requirements and the cart's max loading weight, wheel size, speed and acceleration, the motor's parameters are analyzed and calculated as follows:

$$\mathbf{N_T = 60V_N / \pi D_W} = 60(.37)/\ \boldsymbol{\pi}(.1) = 70.67 \text{ rpm} \quad (23)$$

N_T = Wheel rotation speed = 70.67 rpm, V_N = Nominal robot speed = 1.2 ft/s = .37 m/s, D_W = Wheel diameter = 4 in = .1 m

$$\mathbf{F_T = gkm} = (9.81)(.1)(10.5) = 10.3 \text{ N} \quad (24)$$

F_T = Thrust force = 10.3 N, g= gravitational force = 9.81 m/s^2, k= Max slope =10%= .1, m= Mass of robot = 23 lb = 10.5 kg

$$\mathbf{T_T = ½\ D_w/2\ F_T} = (½)(.1/2)(10.3) = .258 \text{ Nm} \quad (25)$$

T_T = Torque = 0.258 NM, F_T = Thrust force = 10.3 N

The motor used for this project is the VEX 393 motor. This motor has a rotational speed of 100 rpm, and a torque of 1.67 Nm which are higher than the required rpm and torque.

6.1 Software Design

The camera gives visual information to the microcontroller, which then controls the motors based on the program and information received. Pixy2 does not provide any information on distance, so this is done by calculating the area of the landmark, since the pixy provides height and width of objects that it tracks. The area of the object is calculated at various distances (12 ft and 7 inches), and the camera sends the area to the arduino. In order to keep the main function small, there are 3 different void functions; RobotMove, RobotBack, and RobotStop.

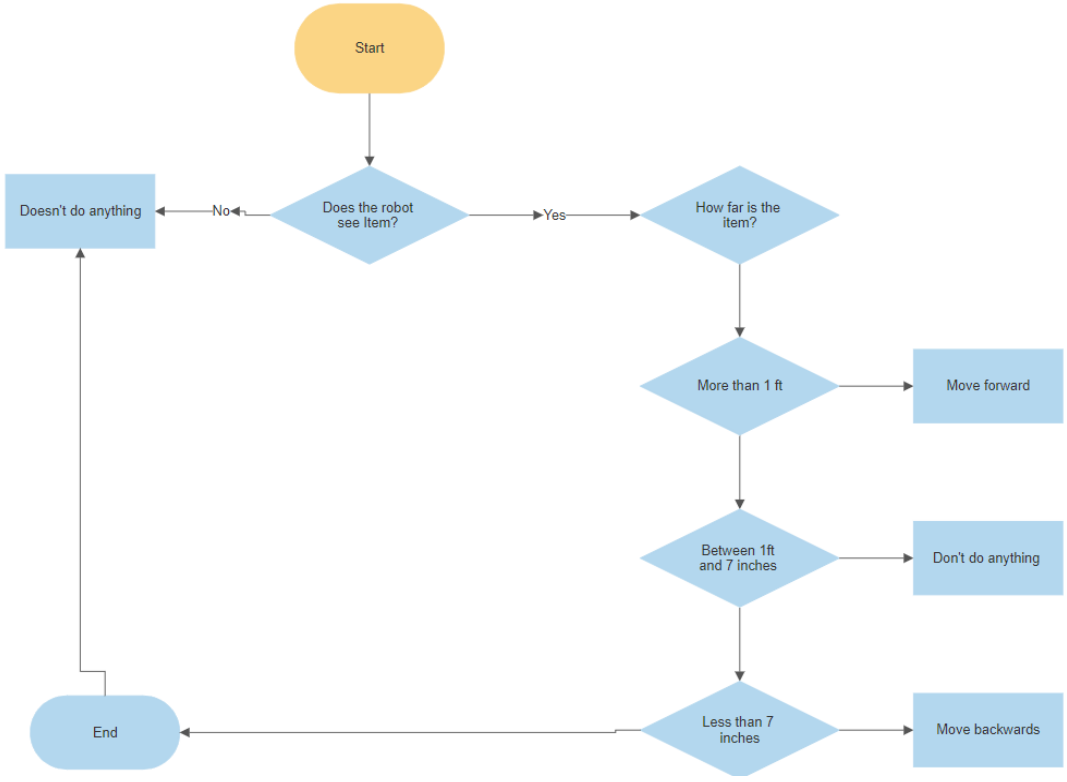

Fig 10: Program Flowchart

6.2 Program

The program used for the project utilizes 3 headers, including the Pixy 2, PIDLoop and Servo header. The Pixy 2 header allows the microcontroller to communicate with the camera and get input information about the items. The PIDLoop header allows the controller to communicate with the servo motor attached to the camera to perform the tilt function and to help the robot understand when to move when panning is required. The Servo header allows the controller to communicate with the microcontrollers and motors via the PWM pins on the arduino, and this allows the programmer to control the motor speed directly.

If the camera sees the object in view and it's been in view for 30 seconds, then it will start following it. If the object is to the left or right of the camera, the robot will physically pivot to face the object. If the object is straight in front of the camera, then the robot will move forward. If the object is 1ft-7 inches away, the robot will not move. If the object is closer than 7 inches, the robot will start moving backwards.

7. Social Impact

Accessibility and inclusivity are two important factors that almost every engineering accomplishment centered on human wellbeing considers. The automatic shopping cart serves the purpose of easing the shopping experience for a wide range of users such as the elderly, the physically impaired, pregnant women, parents who need to watch their children while shopping and, in short, everyone. Additionally, it gives the users the accessibility to walk freely, stop at any moment, move back, and turn into different aisles without having to carry a basket or push a cart.

8. Environmental Impact

In addition to the social and economic impact of the automatic shopping cart, the environmental impact is equally significant. The prototype is built using metal (iron) bars, plastic and lexan, but if it were to be built in a final design, strong biodegradable materials and biodegradable plastics could be used. As a result, this project opens up numerous opportunities to use environmentally friendly materials.

9. Economic Impact

The automatic shopping cart will be financially beneficial for many store owners. The total cost is less than $500, and it is proven that customers tend to come back to stores with smart technology. The shopping cart will be in place to make the shopping experience much easier for anyone since it isn't targeted towards only a specific audience. The shopping cart may reduce shopping time, create an easier shopping experience, and customers will feel appreciated. When people know that an accessible cart is available for their needs, they will return to that store, and store owners will thus experience more profit, as well as a more dedicated and loyal customer base.

10. Conclusion

This project allows the students to apply the knowledge gained from a wide range of courses such as microprocessors, introduction to robotics, electronic circuits, control systems, engineering mechanics, strengths of materials, elements of machine design and finite element analysis. The information provided above and the discussion provided earlier establish the vitality and the prospect of this project. The potential of this project can be further described by the social, economical and ecological impacts it carries. The autonomous shopping cart is inclusive in nature. It opens up the shopping experience to a wide range of customers who have disabilities, as well as to senior citizens. Likewise, in terms of cost, it is very efficient and much cheaper than automatic robots, which are mostly available only for personal use. This product would give shop owners the opportunity for increased profits, perhaps by charging for cart use. Most importantly, the prototype is designed in such a way that provides freedom to explore. For instance, due to feasibility reasons, the body of the prototype is to be built using polycarbonate; however, using materials that are made from plant starch such as PLA (Polylactic acid) would have a highly positive ecological impact.

11. Acknowledgements

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Optimized Water Purification of a Solar Still

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ABSTRACT

On Earth water makes up about 71 percent of the surface. From the composition, roughly 3.5 percent is drinkable, yet less than one percent is accessible for human use. Studies have shown that only 0.007 percent of the Earth's water is available to feed and maintain its population of 7.1 billion people. Nevertheless, around 2.1 billion people don't have access to filtered water, and this is already a growing crisis. The average human needs 2 liters of water a day to live, in many regions of the world water is trapped in other materials such as mud and sand or contaminated by bacteria and other harmful substances. There are many methods of retrieving this valuable resource, but they are niche and sometimes require chemicals that need to be refilled. One of the largest factors is how ambient temperatures throughout the world affect the methods of purification. The team will design a water purification system that requires minimal maintenance, that's not reliant on ambient temperatures, and is highly cost effective. They will run an analysis on how much water is purified in a certain time span and optimize it.

1. Introduction

All life needs water to survive. Nomadic humans originally obtained water from springs, ponds, and rivers. Once humanity started developing sedentary agriculture, they needed reliable access to water, this building around rivers and wells. The water they obtained came from and was cleaned by the water cycle. The core mechanics in the water cycle is evaporation and condensation, where water from lakes, rivers, and the ocean evaporate and condensate into clouds in the atmosphere from which the now clean water falls back into the rivers and lakes. Humans have had access to clean water for over 10,000 years, yet according to the CDC roughly 11% of the world's population lacks access to an improved water source and a further 25% of the population lack proper sanitation, CDC [1]. This is due to the sources of water being contaminated or completely undrinkable. There are many solutions to this problem, but most purification methods are expensive and require large amounts of energy, but a solar still can purify water using only the energy from the sun. Using the water cycle as an example, a solar still can evaporate water and cause it to condensate on a surface and collect it in a container.

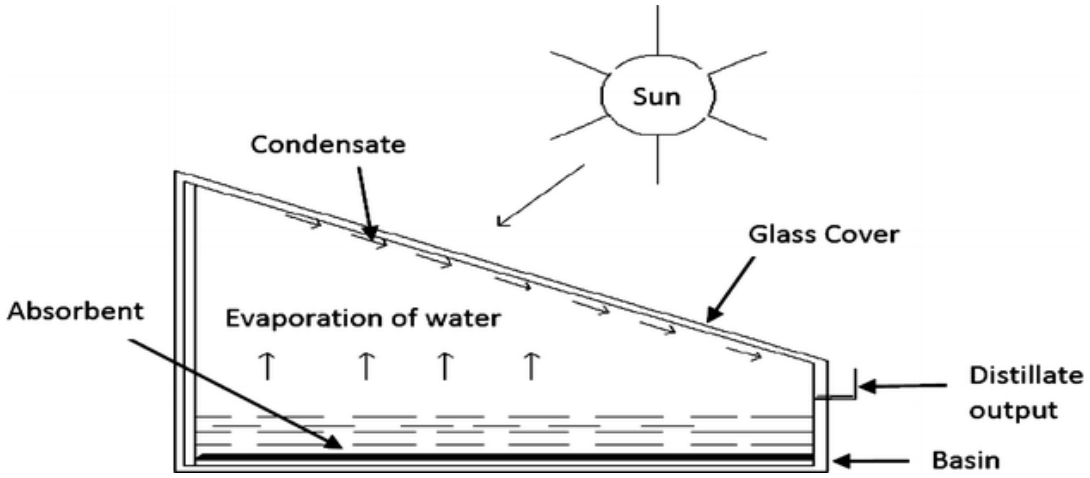

Figure 1: A basic diagram solar still

The concept of Evaporating and Condensing water has existed for hundreds of years; back in the 1600's alchemists would use this method to purify water. It was not until 1872 that the first large scale solar still plant was built to output distilled water. This plant could produce 23,000 liters of water per day for a mining community nearby. Modern day solar stills have developed since then and are designed to be more portable and easier to set up. These solar still can be used to provide water to more isolated communities. There are also solar stills designed to float on water, these can be used to create water if a ship has an emergency and does not have enough clean water storage or power to purify water from the sea on its own.

2. Project objective

The project aims to design a portable and sustainable water purification system using a solar still:

1. Optimize Solar Still Purification

The device will use the sun as an energy source to heat the water causing it to evaporate. The water will then condense on a colder upper surface and be collected. Doing this allows the device to work almost anywhere without complex infrastructure like modern gas and electric.

2. Portable and Reliable

The device would need to be light enough to be portable by vehicle or people. It would also need to take minimal space in order to supply a large number of them to various areas. Getting the device to many areas relies on the device being able to function reliably in many different environments.

3. Reusable and Cleanable

As the water being evaporated, will likely contain various debris like mud or salt, which can lower the device capabilities of absorbing in the sun's energy, the system should be easily cleaned. Once used the device needs to still be capable of functioning and capable of being transported elsewhere if needed.

3. Social and Environmental Impact

Water is vital to human survival in any environment; at most the average person can survive 3 days without it. On top of this many sources of water in some regions are contaminated with hazardous particulates. Having an easy and safe way to purify water that requires little human effort to produce could radically shape how hospitable the world is to humans in more extreme environments.

4. Economic Impact

The cost of an Aquamate Inflatable Solar Still is $238.00 (rounded up) while the cost of materials for the still was around $200.00 but it would have been reduced if a larger amount of materials were bought from the manufacturer. The Aquamate needs to be set into water while this one needs to be on solid ground and filled to a desired amount. This greatly limits the available biomes for their product, while this still necessitates water inside of the reservoir.

5. Application

Access to clean water is necessary for human health; this device being able to produce clean water can see use in any rural area where clean water is scarce or non-existent. This can include rural areas in Africa and Asia who constitute the majority of people without access to potable water. Similarly, the device can be used on boats in order to turn the endless supply of saltwater into potable water allowing for ships to sail for longer periods of time.

6. Engineering requirements

From the design objective of producing a water purification unit, the engineering requirements include:

1. The ability to purify water to a potable level in a reasonable amount of time.
2. The device must also be cheap and transportable, minimizing space and weight required to deliver it to locations.
3. The design needs to function in areas where there is little access to clean water and as such must have a reliable output of potable water.
4. The evaporated water will leave behind debris and contaminants, in order to maintain consistent supply, the device must be easily and safely cleanable.

7. Engineering Constraints

1. Costs: less than 600$
2. Weight: no more than 100 lbs. empty
3. Volume: should compress to fit within: 2ft x 2ft x .25ft Box (0.6m x 0.6m x 0.076m
4. Materials:
5. Cover: Needs to be transparent and not contaminate water when in contact
6. Heater: Lightweight, waterproof powered by battery.
7. Base: structurally sound and thermally resistive

8. Engineering Design

The first design of the still was a hexagonal shape with the collection channel in the center. The main feature of this design was the hexagonal shape and the additional Reflective surfaces.

One of the main negatives of the design would be increased Complexity, increasing the cost of manufacturing. The design also had less surface area and internal volume while fitting in the required space, this results in a decreased production of water as surface area and water production are directly related.

It was decided to go with a more simplistic design for the reservoir and design around that. Using Solid Works, the first step was to design it with an area large enough to hold at least 2 kg of water, catch as much sunlight as possible, and keep the depth of the reservoir low. As seen below in Fig. 2. The area chosen was 4 ft^2 and 8-inches in height in the back with 6-inches in the front to create a slope.

The second step was to make the box watertight through only mechanical means; the lack of one-use materials was a vital design philosophy for us. A corner connector was made as seen below in Fig. 2; the water levels did not need rise to the full height of the wall. This was to prevent having to cut the connector at the 5-degree angle that the side wall will be cut at. The minimum height however is 5 inches, the same height as the designed maximum water level. Due to the water level only being 5 inches in the whole system it only needed to be watertight up to this level, however the rest of the still needs to be mostly enclosed to limit air from leaving the system, so an overhang was designed on the walls to create a tighter seal. This only increases the number of required cuts by 4 so it does not increase complexity or production costs by much.

The next step in the process was to optimize the area used for evaporating the water. The parts of the reservoir were simple, but it was un-optimized for wider ranges of environments. To overcome this, a floating heater, a solar panel with its stand, a battery, and a battery were added.

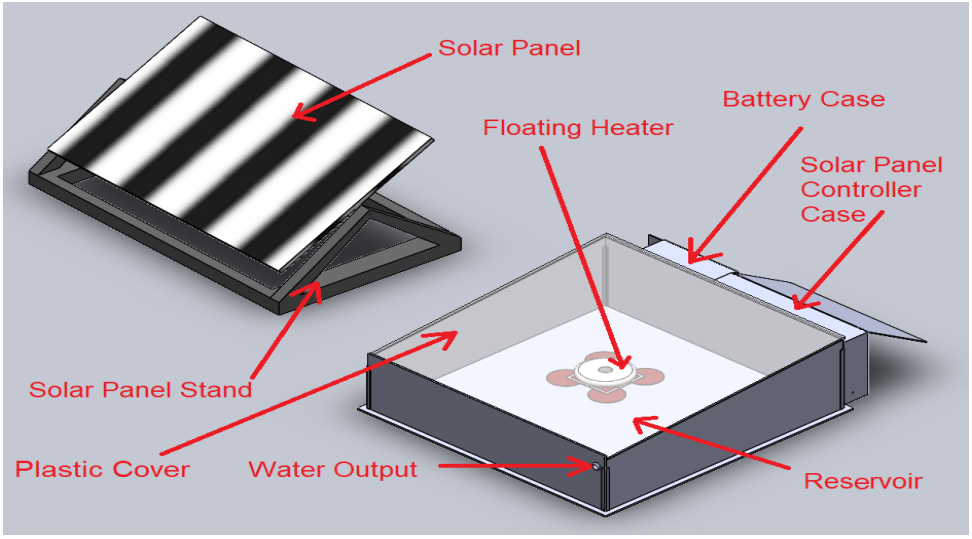

Figure 2: The full system with all optimization components

The heating element shown in Fig. 3 was for conceptual purposes, four waterproof silicone heating pads will be used but the floatation device design will be dependent on the necessary spacing needed for each heater. Each pad can reach a temperature of around 150 degrees Celsius with a necessary wattage of 7 per hour.

This was included to better maximize evaporation in less-than-ideal ambient temperatures, there was much doubt that this could ever match the rate of the ideal amount evaporated in a day. This allowed the still to at least maintain a more constant rate of purified water on a daily basis. The optimal spacing between each pad will have to be done once they are tested on the surface of the water.

Below in Figure 3 is a 50W 12V solar panel attached to a simple stand setup to angle it for maximum sunlight intake. This specific type of panel was selected to complement the heating elements. The purpose of this solar panel is to charge the battery while the heater drains it. Assuming perfect weather conditions it should be able to keep the battery fully charged until sunset ends.

The use of the solar panel is to utilize more energy from the sun without taking away energy from the main system. This in tandem with the battery and Heating elements allowed the still to be used in a wider range of environments without needing any outside interference. Fig.3 shows an example of the intended flow of the system, mimicking the water cycle.

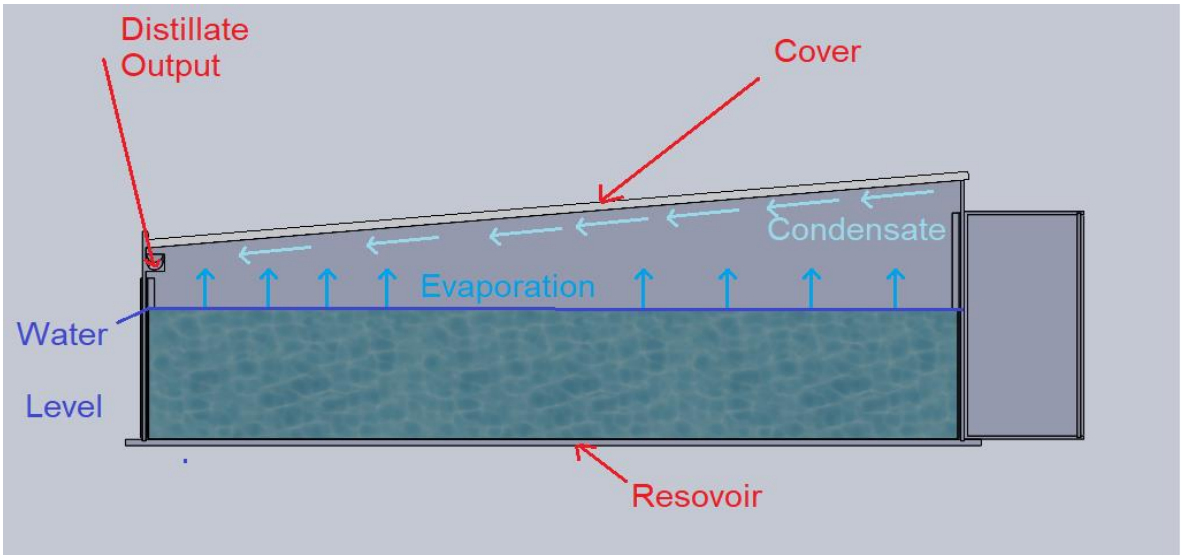

Figure 3: Model of system workflow

Casings were added to the back of the box in order to protect some of the sensitive equipment. Seen below in Figures these also provided routing for the electrical cables needed to charge the battery and power the heating elements. One has a sliding door and the other has a door hinged at the top to enable quick access while also protecting them from the environment.

A 12-volt 23-amp hour battery would be used to power the heating elements for at least 5.67 hours off of a full charge. Given perfect weather conditions the solar panel could charge the battery at roughly the same rate as the heating elements are draining it.

The solar controller would have come with the solar panel selected. Its function was to regulate the power outputs and inputs between the solar panel, battery, and heating elements.

The theoretical full system as seen below in figure 12 would need around 8 sq.ft of space around and in direct line of sunlight throughout the day to allow for maximum efficiency.

9. Prototype

The creation of the prototype used several acrylic sheets to form the base and sides of the still. Adhering each piece with epoxy and setting a pipe on the inside the still was then set outside, filled it with water up to the 10mm level in height, and set the collection bottle to start evaporation. The completed structure can be seen below in Figure 4.

Figure 4: Still set out for testing

Each day, evaporation was induced in the system throughout the day. Fig. 5 below shows the evaporated water pooling on the plastic sheet after a few hours in the sunlight.

Figure 5: Evaporated water collecting on the ceiling of the still

10. Mathematical Formulation

Buoyant force: The buoyant Force Formula is used because the solar Still Design needs a floating heater to increase productivity and the heating pads need to be kept below the water.

$$F_b = -\rho g V \quad (1)$$

Where: $\mathbf{F_b}$**=** Force of buoyancy, **ρ=** Fluid Density, **G** = Force of gravity,
V= volume of liquid displaced

Solar panel Energy production: This formula is used to determine the output of the solar panel; this determines how much energy needed to power the heaters. This formula can also be used to calculate energy absorbed by the water.

$$E = ArHPR \quad (2)$$

Where: **E**= Energy, **A**= Area of solar panel, **r** = efficiency of solar panel, **H** = Average solar radiation, **PR** = Performance Ratio

Conduction Heat Transfer: This formula is used to determine potential heat loss to the environment through the walls and base of the solar still.

$$\dot{Q} = kA(T1-T2)\Delta x \quad (3)$$

Where: $\dot{Q}$**=**Heat Transfer, **k**= Thermal Conductivity, **A**= Area of wall, **T1=** Inside temperature, **T2=** Outside Temperature, **Δx=**Thickness of the wall

Thermodynamic Of model for Solar still

Mass flow rate of Distillate output: This formula is used to calculate the output of the solar still based on the temperature of the water and of the cover. This leaves an answer in L/s*m^2, so you can then multiply by the area of the still ours being .37m.

$$\dot{m} = q_{evp} * h_{fg} \quad (4)$$

Where: $\dot{m}$=Mass Flow rate per meter squared, q_{evp}=Heat transfer from evaporation, h_{fg}=Latent heat of vaporization of water

Heat Transfer from Evaporation: This formula is used to calculate the heat transferred from the water to the cover, this is needed to calculate the output of the system.

$$q_{evp} = 16.276 \text{ X } 10\text{-}3 q_{cw}(p_w - p_g)(T_w - T_g) \quad (5)$$

Where: q_{evp}=Heat transfer from evaporation, q_{cw}= Heat transfer from convection, p_w=Partial pressure of water vapor at the water's temperature, p_g=Partial pressure of water vapor at the Cover's temperature, T_w=Temperature of water, T_g=Temperature of cover

Heat Transfer from Convection: This formula is used to calculate the heat transfer through convection from the water to the cover, this is essential in calculating the heat lost through evaporation.

$$q_{cw}=.884[(T_w-T_g)+(p_w-p_g)(T_w-273)(268.9 \text{ X } 10^3-p_w)]1/3(T_w-T_g) \quad (6)$$

Where: q_{cw}= Heat transfer from convection, p_w=Partial pressure of water vapor at the water's temperature, p_g=Partial pressure of water vapor at the Cover's temperature, T_w=Temperature of water, T_g=Temperature of cover

Heat transfer from radiation: This formula is used to calculate the heat loss from the water to the cover by radiation. The heat loss from radiation is needed to calculate the temperature of the basin.

$$qrw=\varepsilon\boldsymbol{\sigma}((Tw+273)4-(Tg+273)4) \quad (7)$$

Where: qrw= Heat transfer from radiation, ε=Emissivity of water, $\boldsymbol{\sigma}$= Stefan-Boltzmann constant, Tw=Temperature of water, Tg=Temperature of cover

Energy Equation of the solar still: This equation can be used to calculate the total heat transfer of the solar still system.

$$M_wdTwdt=Q_s+Q_h-(q_{rw}+q_{cw}+q_{evp}) \quad (8)$$

Where: $\mathbf{M_w}$**=** Specific Heat Capacity of water, **dTwdt=**The change of temperature of the water over time, **Qs=**Heat gained from solar radiation, $\mathbf{Q_h}$**=** Heat gained from Heating pads, $q_{\mathbf{rw}}$= Heat transfer from radiation, $q_{\mathbf{cw}}$= Heat transfer from convection, $q_{\mathbf{evp}}$=Heat transfer from evaporation

11. Analysis

The first step taken in analyzing the solar still was to find the mass flow rate of purified water produced by the still. This is done using Eq.4 which defines mass flow rate as a function of evaporative heat loss divided by the specific heat capacity of water. Two equations are required to find the evaporative heat loss, i.e. Eq.5 and Eq.6. To use these equations, the temperature of the cover was assumed to be constant. The vapor pressures were then found from table 2. The temperature and pressure values were used in Eq. 5 and Eq.6. Results can then be substituted into Eq.4 from which the mass flow rate is calculated. This was done multiple times varying the temperature of the water; the results are graphed in and tabulated in Fig. 6 and table 1 respectively. The processed is shown as follow

Given that Tw = 60 °C, Tg = 5°C and from table 2 it can be found p_w = 19.932kPa and p_g =.6113kPa and hence from equation 6 convection heat transfer can be calculated as follow

$$\mathbf{q_{cw}=.884[(60-5)+19.932-.6113\ 60-273268.9\ X\ 103-19.932]13(\ 60-5)=62.63}$$

Substituting the temperatures, pressures and q_{cw} into Eq. 5, evaporated heat can be calculated as follow

$$\mathbf{q_{evp}=16.276\ X\ 10-3q_{cw}(19.932-.6113)(60-5)=0.358}$$

Finally, using q_{evp} into Eq.4 gives the mass flow rate of distilled water from the system per square meter.

$\dot{m}$ = 0.358645 kg/hour*m²

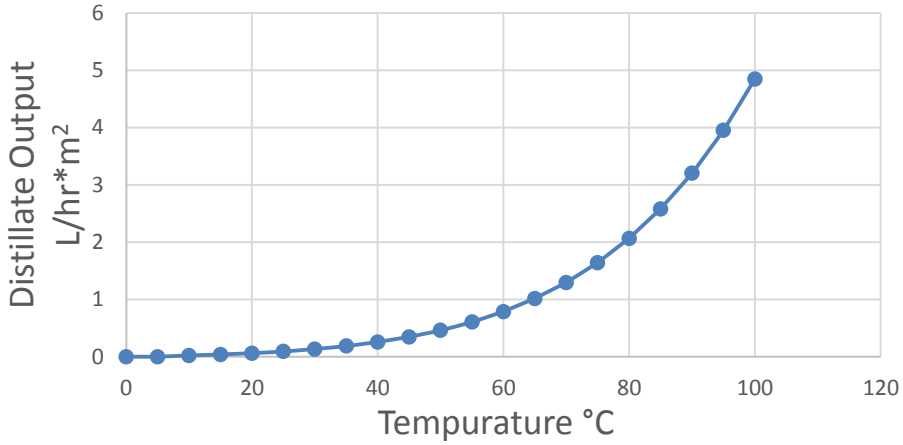

Figure 6: Distillation output vs. Temperature

Table 1: Water output for each temperature if constant for the whole day [10]

Temp	Partial Pressure	qcw	qevp	Total Energy in an hour J	Distillate output L/Hm^2
0	0.6113	-4.42	0	0	0
5	0.8726	0	0	0	0
10	1.2281	4.80271	0.009643	13.8857992	0.021232109
15	1.7056	9.772036	0.017405	25.06291707	0.038322503
20	2.3388	14.89723	0.027924	40.21078008	0.061484373
25	3.169	20.18212	0.042008	60.49182277	0.092495142
30	4.2455	25.63575	0.060654	87.34237591	0.133551034
35	5.6267	31.26969	0.085085	122.5231169	0.187344216
40	7.3814	37.09707	0.116792	168.1809408	0.257157402
45	9.5898	43.13196	0.157576	226.9097745	0.346956842
50	12.344	49.38892	0.209586	301.8041239	0.461474196
55	15.752	55.88352	0.275428	396.6156855	0.606446002
60	19.932	62.63042	0.358091	515.6507528	0.788456809
65	25.022	69.64552	0.461179	664.0982166	1.015440698
70	31.176	76.94454	0.588887	847.9979041	1.296632881
75	38.563	84.54266	0.746031	1074.284466	1.642636799
80	47.373	92.45554	0.938231	1351.052303	2.065829209
85	57.815	100.6987	1.17194	1687.594036	2.580419015
90	70.117	109.2871	1.454515	2094.501797	3.202602135
95	84.529	118.2362	1.794358	2583.876228	3.950881083
100	101.32	127.5605	2.200935	3169.346582	4.846095691

As discussed above and shown in Fig.6, the water output is highly dependent on the temperature of the water, so a formula was needed to calculate the temperature of the water throughout the day. The Temperature of the water is based on the thermodynamic properties of the system. Based on the first thermodynamic law energy can neither be created nor destroyed this means that the change in temperature of the water is equal to the energy input minus the energy lost. This is shown in Eq.8 which was derived after making a few assumptions.

- The first assumption is that the cover would be a constant temperature based on the environment.
- The second assumption is the basin would be the same temperature as the water and lose no heat to the environment.

The solutions to Eq. 8, Eq. 7, Eq.6 and Eq.5 were used to find the heat loss and find how much energy the solar still gets from solar radiation and heating pads. The solar radiation varies based on weather, latitude, and time of the year while the heating pads can provide a constant 42 watts. The solar energy into the still can be calculated using Eq. 2 with the solar radiation being taken from Ref. [10]. These equations were then used in intervals of 1 hour to estimate the temperature of the system given certain starting conditions. These starting conditions include starting water temp, Cover temp, solar efficiency, solar radiation, and heating from the heat pads.

Table 2: Vapor Pressure of Water at Various Temperatures

Vapour pressure of water (0—100 °C)

T, °C	*T*, °F	*P*, kPa	*P*, torr	*P*, atm
0	32	0.6113	4.5851	0.0060
5	41	0.8726	6.5450	0.0086
10	50	1.2281	9.2115	0.0121
15	59	1.7056	12.7931	0.0168
20	68	2.3388	17.5424	0.0231
25	77	3.1690	23.7695	0.0313
30	86	4.2455	31.8439	0.0419
35	95	5.6267	42.2037	0.0555
40	104	7.3814	55.3651	0.0728
45	113	9.5898	71.9294	0.0946
50	122	12.3440	92.5876	0.1218
55	131	15.7520	118.1497	0.1555
60	140	19.9320	149.5023	0.1967
65	149	25.0220	187.6804	0.2469
70	158	31.1760	233.8392	0.3077
75	167	38.5630	289.2463	0.3806
80	176	47.3730	355.3267	0.4675
85	185	57.8150	433.6482	0.5706
90	194	70.1170	525.9208	0.6920
95	203	84.5290	634.0196	0.8342
100	212	101.3200	759.9625	1.0000

The distillate production of a solar still is based on the thermodynamic properties of the system.

12. Industry Design Standard

The water output must meet or exceed the EPA's guidelines for water for human health. This would be achieved by having lower than the public health goal of contaminants for various contaminants such microorganisms, organic chemicals, and disinfectants [11]. This will be done due to the fact during evaporation only the lightest materials will be able to lift to the top of the still and be collected.

13. Experimental Results

As can be seen in Fig. 5, evaporated water was collected on the stills. The amount collected was approximately 100mL. This can be seen in Fig. 7.

Figure7. Water bottle with 100mL of water collected.

The reason for the small amount of water collected is due to lack of budget for material and machining as well as poor weather conditions and not enough slop being given to the cover to allow the water to collect in the channel. This will be addressed in future work by increasing the slope of the cover. More need to be secured to make another prototype with tighter tolerances and include some of our additional feature like a floating water heater and reflective cover.

14. Cost Analysis

The Total necessary budget was roughly $500.00 but the given budget by the CSTEP program was $200.00 because of this it was decided to leave out any non-essential materials to prioritize only the most needed to the project. The team bought the necessary polycarbonate sheets and pipe, then seeing unallocated funds the team added the one-way mirror film and the pack of heating elements. The group chose these to luxury materials because they can increase the efficiency of evaporation with the least amount of cost.

Table 3: Itemized list of needed Materials for a full prototype

Item	Qty	Description	Unit Cost	Total
PVC Pipe	1	PVC Pipe Sch40 3/4 Inch (0.75) White Custom Length - 3FT	$7.95	$7.95
Acrylic Sheet	1	Simba Lux Acrylic Sheet Black Opaque Cast Plexiglass 12" x 24" Long Panel 1/8" Thick (3mm)	$21.95	$21.95
Solar Free One-Way Window Film	1	Solar Free One-Way Window Film Mirror Reflective Privacy Window Tint	$39.98	$39.98
Polyimide Heater Plate Adhesive	1	Icstation 12V 13W Flexible Polyimide Heater Plate Adhesive PI Heating Film 70mm Round (Pack of 4)	$15.99	$15.99
Polycarbonate Sheet	1	Polycarbonate (PC) Sheet, Impact Resistant, Opaque Black, Standard Tolerance, ASTM D3935, 1/4" Thickness, 24" Width, 48" Length	$97.16	$97.16
Solar Panel	1	20W 12V solar panel	$52	$52
Battery	1	Dakota Lithium 12v 23Ah Battery	$249	$249
Total:				**$255.00**

14. Discussion

Due to limitations which will be addressed in future work, the experiment output only 100mL of distilled water. The team had noticed the water evaporating before peak sunlight and noticed that the pipe was not collecting the evaporated water; this was due to the fact that the uneven cuts on the pipe led to holes in the contact between it and the side wall. After properly attaching the pipe, it was found that none of the water which accumulated on the plastic dripped into the pipe. The group then realized that the angle formed from the size of the still was not great enough to make all the distilled water flow into the pipe. Ultimately the cover was titled to a steeper angle, in which the water would flow, and the water was then collected this added up to a total of 100mL of water produced in one day.

Two theoretical scenarios coming from near inhospitable environments were used. The team loaded the model with a solar still without using any optimizing components and using the same environment while adding the external and internal optimizing components. The environmental parameters around likely weather conditions such as an outside temperature 5 deg Celsius above freezing, with maximum sunlight hitting the still for 14 hours, the water level roughly 10mm high, only 50% of the sun's energy being reflected out of the system, and a starting temperature of the water at 7 deg Celsius.

This led to the model theoretically getting roughly 1.56 liters in distilled water per day. Without any added optimizing components, it wouldn't produce enough water on a ~7 deg Celsius day to sustain 1 person.

Resetting the calculations for the added optimization, utilizing roughly 85% of the sunlight coming into the system using the one-way mirror film and use the heating element-battery system to add 42 watts of energy during sunlight hours which would continue in inducing evaporation for an additional 2~3 more after sunset. It was calculated that the still could get 5.794 liters of clean water per day, that amount could sustain almost 3 people with enough water to survive.

The test on the system was repeated with the mirror film and without the heating system affecting it. Calculated using these parameters the model got approximately 4.27 liters in the same environment. Further testing into varying environmental conditions with this system modification it was shown that using only the reflective film on the worst possible day with sunlight, January 1st and with an estimated outside temp of -5 degrees would possibly distill 1.1 liters versus the best possible day, June 25 with an estimated temperature of 20 degrees Celsius showed that the still could get 10 liters of water.

The one-way film is the best optimization factor for the still in terms of utilizing weather conditions and sunlight while the heating system is best used for expanding the range of weather conditions usable for the still.

16. Conclusion

In conclusion while the team collected only a small amount of water, approximately 100ml. Many improvements were noted for future iterations. The angle of the plastic covering needed to be greater than ~5 degrees to allow for a better flow of water into the pipe. The pipe itself would be set at a slightly lower angle to increase the flow of water into the collection vessel. The opportunity did not arise to test the heating elements, if given future iterations testing to find optimal spacing would be needed. The mirror film never arrived; it remains to be seen how it would actually affect the experiment. Further development of this project could cause major change in how water is purified in many climates of the world. This project utilized all of the group's collective knowledge of Thermodynamics, Heat Transfer, and SolidWorks to find the amount of water distilled in any given environment. Knowledge of how to calculate, find, and solve for heat transfer coefficients, convections rates, and energy loss was vital to this project. If not for those calculations,the team would have no metric to measure the stills efficiency.

17. Acknowledgement

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The Use of Thermo-Electric Generators to Recycle Thermal Energy produced by Electronic Components for Convection Cooling

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Abstract

As collaborated as a team, the main aspect for this project follows the principle of converting the transference of heat into electricity. This is known as the Seebeck effect, as temperature difference produces a voltage to an extent where it drives an electric current in a closed circuit. The thermoelectric generator was designed as an alternative source in producing renewable energy while reducing the reliance on energy that produces harmful emissions into the atmosphere. However, the thermoelectric generator is limited in its current inability to produce over a 5% efficiency rate. The objective of this project is to design a long-lasting, affordable, and effective thermoelectric generator to convert the wasted heat generated from desktop computers into electricity. This will then be used to generate power to operate the cooling fans. Attempts will also be made into increasing the efficiency threshold produced by the thermoelectric generator while taking into consideration the spacing available within the desktop computer's structure. The product will serve as a transition to renewable energy for the electronic device industry.

1.0 Introduction

Theoretical application of thermoelectric generators predated towards the 19th century where the earliest known study of thermoelectricity was done by Thomas Seebeck in 1821. During this study, Seebeck discovered that a circuit made from two dissimilar metals, with junctions at differing temperatures would deflect a compass magnet. In which case, this project focuses on the Seebeck effect, for the development of a long-lasting and effective thermoelectric device.

Computers used by students usually have more than 1 application performing at once and this can cause overheating in the system. The thermoelectric device will provide additional cooling during stressful applications and possibly during normal usage. This additional cooling would

reduce the cost per watt usage of the computer by diverting the cost to cool the computer and promote the health of each computer component. With each new generation of computers, the ability to compute complex problems becomes quicker and more reliable. This improvement comes at the cost of increasing wattage use and excess heat waste as a result. This would reduce the reliance on non-renewable resources as a source of fuel and cost to power everyday appliances and electrical devices.

1.1 Social Impact

Due to the nature of our project, there is no inherent social impact. However, with enough time, we could explore this section of the project. Some thoughts were taken into consideration over conducting a broad survey on the desirability of having the TEG device pre-installed on the computer build at the increase in cost. Another proposition was contacting the computer manufacturers and discussing the feasibility of adding a TEG device on a built computer.

1.2 Environmental Impact

Another main goal for this device is to maximize energy efficiency. The device should be able to produce a perceivable difference in energy consumption and component temperature. Performance improvements in computers have come at the cost of increasing wattage use and excess heat waste as a result. The application of this product will reduce the heat wastage generated from computers from energy conversion in the transference of heat to generate electricity. As a result, this will operate the desktop's cooling fans and this would reduce the reliance on non-renewable resources as a source of fuel and cost to power everyday appliances and electrical devices.

1.3 Economic Impact

Most computer parts are continuously becoming more efficient with power consumption with an upward trend in thermal design power for each generation. Currently, the trend of society leans towards renewable energy. Considering that the majority of households in developed countries have access to computers, the usage of this device will not only serve to support this renewable energy trend through reusing wasted heat but also maximizing the energy efficiency of modern-day computers. This in turn would reduce the cost that consumers would otherwise have to pay towards their electricity bill. The focus is to have a thermoelectric generator to be affordable enough to install on computers where the cost of the one-time purchase of the TEG device would be offset by a decrease in electricity cost overtime to promote its use in every household. The cost of installing a TEG device would also decrease as TEG technology improves over time which would make this project more feasible for the average desktop computer.

1.4 Engineering Standard

The following listed below are the engineering standards followed by each component used in this project:

1. Computer Casing - The type of casing is an ATX mid-tower computer standard. The casing should hold all ATX components. The acronym "ATX" stands for advanced technology extended, which represents a motherboard specification that defines the board's physical

dimensions, connector placement, and support power supply.
2. Power Supply - 750 watts, 80+ rated gold standard.
3. TEG - The acronym "TEG" stands for thermoelectric generator. The size standard is 40 mm by 40 mm by 5.1 mm. TEG type is the scavenger unit module. The orientation of TEG has both hot side and cold side with the hot side labeled on the TEG module. The material used to manufacture the TEG module is Bismuth Telluride.
4. Heat Sinks - The size standard is 50 mm by 50 mm by 20 mm. The material used to manufacture the heat sinks is 6061 Aluminum.
5. Flat Plate - The size standard is 304.8 mm by 152.4 mm by 6.35 mm. The size was customized to 142 mm by 145 mm by 6.35 mm. The material used to manufacture the flat plate is 3003 Aluminum.
6. Holes - The drill size standard follows the American Standard of Mechanical Engineers (ASME) guidelines. The diameter of the hole is 4.3 mm.
7. Wires - The diameter standard (gauges) is the 24 or 26 gauge wire.
8. Battery - The voltage standard is 1.5 volts.
9. Voltage Converter - The voltage standard is ranged from less than 1.5 volts boosted to 5 volts. The efficiency standard is between 80% and 95% efficiency.
10. Desktop Cooling Fans - The size standard is 120 mm by 120 mm. The power standard is 0.75 watts.
11. Nuts and Bolts - The diameter and pitch standard follows the American Standard of Mechanical Engineers (ASME) guidelines. The standard for the bolt type is a socket cap bolt. The diameter of the bolt is 4.0 mm with a clearance of 0.3 mm. The pitch size of the bolt is 4 mm in diameter by 0.7 thread per mm. The property grade is set by the American Standard of Mechanical Engineers (ASME) guidelines.

1.5 Engineering Requirements

The following is a list of all known engineering requirements that must be met to successively conduct the installation of the TEG device on the power supply and operate two 5 volt desktop fans based on the experiments conducted within this project:

1. The voltage output required from the TEG device to power a desktop cooling fan must meet the minimum of 5 volts.
2. The current output required from the TEG device to power a desktop cooling fan must meet the minimum requirement of 0.5 amps.
3. The TEG device must be able to supply enough power to operate two desktop cooling fans.
4. The total power output required from the TEG device to power two desktop computer fans must meet the minimum requirement of 1.5 watts.
5. The temperature difference between the hot side and cold side of the TEG modules must meet the minimum requirement of 5 °C
6. The factor of safety required securing the connections of the bolts, soldering points, wires, and the power supply case must meet the minimum requirement of 1.5.
7. The shelf life requirement of the TEG device should last for a minimum of 5 years.
8. The use cycle requirement of the TEG device must be able to operate two computer fans for a minimum of two hours.
9. The computer airflow for the computer fans must meet the minimum requirement of 70 CFM.

1.6 Engineering Constraints

The following is a list of all known engineering constraints that limit the scope of the project based on time, cost, and accessible space:

1. The dimensional constraint over the accessible build area within the desktop computer was limited to 152 mm by 152 mm by 120 mm.
2. The dimensional constraint over the accessible surface area of the power supply was limited to 140 mm by 150 mm. The accessible surface area limits how many TEG modules can be placed effectively.
3. The orientation constraint is based on the power supply being limited to only one workable side where the TEG device will be implemented.
4. The temperature constraint is based on the maximum temperature limit of the power supply which was measured at 54.44 °C.
5. The cost of the TEG device should meet the maximum price constraint of $200 for its feasibility of purchase.
6. The TEG module size constraint is limited to its dimension of 40 mm by 40 mm by 5.1 mm.
7. The time constraint based on the use of the computer should operate at a minimum of half an hour for the temperature of the power supply to reach its steady-state.
8. An isolation constraint is needed for having a case applied over the power supply and electrical circuit to prevent any potential electrical hazards that may damage the components in the computer.

2.0 TEG Modules Calculations and Comparison

The TEP1-12635-3.4 module and TEG2-126LDT module were compared to identify which of the two modules would be most optimal upon creating a series-connected TEG device. Two key variables that should be identified to determine this are conversion efficiency and heat absorbed. The first task was through analyzing the pdf files obtained from the manufacturer's website for the technical data of each module and listing them as shown in table 1.

Table 1: Module Technical Data Sheet of Three Different Modules

	TEP1-12635-3.4 Module	TEG2-126LDT Module
Hot Side Temperature (K)	**300 °C**	**200 °C**
Cold Side Temperature (K)	**30 °C**	**30 °C**
Matched Load Output Voltage (Volts)	**5.4 Volts**	**4.3 Volts**
Matched Load Output Current (Amps)	**1.0 Amps**	**0.7 Amps**
Matched Load Output Power (Watts)	**5.4 Watts**	**3.0 Watts**

Estimated Length of Thermocouple (Meters)	$\mathbf{3.4 * 10^{-3}}$**Meters**	$\mathbf{5.1 * 10^{-3}}$**Meters**
Estimated Cross-Sectional Area of Thermocouple	$\mathbf{1.96 * 10^{-3}}$**Meters**	$\mathbf{2.25 * 10^{-3}}$**Meters**
Estimated Number of Thermocouples	**127**	**126**

Different sample TEG modules technical data were examined to replicate the calculations made using the formulas provided in the pdf (refer to reference 5). It should be noted that the temperature was converted into kelvin from degrees Celsius before conducting the calculations.

After comprehending how the calculations were completed, the procedure was repeated for the TEP1-12635-3.4 and TEG2-126LDT modules using the data shown in table 1. The thermal conductivity of the TEG module was obtained by identifying the base material of the TEG module. The most common material used in the makeup of the TEG modules was Bismuth Telluride. As such, the thermal conductivity of the identified material was 1.5 Watts/m°C

The cross-sectional area and length of the thermocouple were obtained based on the approximation for the cross-sectional area and the height of the TEG module for the length. The diagram in figure 2 shows the method of measuring the necessary dimensions that would be used in calculations of the unknown variables.

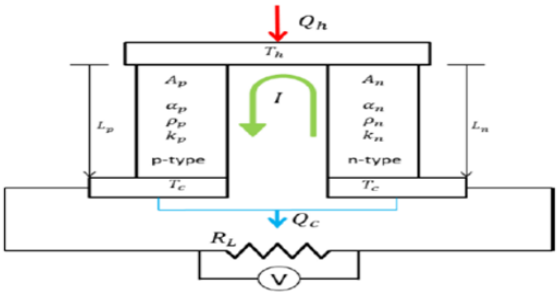

Figure 2: p- and n-type Unit Thermocouple for a Thermoelectric Generator

The first step in the calculations is to solve for the Seebeck coefficient and volume resistivity for both TEG modules using equations 1 and 2. The thermal conductivity "k" was identified to equate to 1.5 Watts/m°C for Bismuth Telluride. The Temperature is calculated in kelvin using the hot side temperature and cold side temperature of the TEG module. The known values for the Seebeck coefficient, volume resistivity, and thermal conductivity are then applied into equation 3, which is then multiplied with the average temperature of the TEG module to obtain the figure of merit needed to calculate the heat absorbed by the TEG device.

$$\alpha = \frac{4W_{max}}{nI_{max}(T_h - T_c)} \quad \textbf{(1)}$$

$$\rho = \frac{\left(\frac{4\left(\frac{A}{L}\right)W_{max}}{n(I_{max})^2}\right)}{2} \quad \textbf{(2)}$$

$$Z = \frac{\alpha^2}{\rho k} \quad \textbf{(3)}$$

$$\underline{ZT} = Z\left(\frac{T_h+T_c}{2}\right) \quad (4)$$

The next step was calculating the internal resistance and current of the TEG module using equations 5 and 6. The length "L" and cross-sectional area "A" of the thermocouple were measured using figure 2 as a visual guide while the variable n represents the number of thermocouples the TEG module has in total. The internal resistance of the TEG module would then be used to calculate the max voltage, max power output, and conversion efficiency of the standalone module using equations 7, 8, and 9.

$$R = \frac{\rho_p L_p}{A_p} + \frac{\rho_n L_n}{A_n} \quad (5)$$

$$I = \frac{\alpha(T_h-T_c)}{R_L+R} \quad (6)$$

$$V_n = \frac{n\alpha(T_h-T_c)}{\frac{R_L}{R}+1}\left(\frac{R_L}{R}\right) \quad (7)$$

$$W_n = \frac{n\alpha^2(T_h-T_c)^2}{R}\frac{\frac{R_L}{R}}{\left(1+\frac{R_L}{R}\right)^2} \quad (8)$$

$$\eta_{mp} = \frac{\left(1-\frac{T_c}{T_h}\right)}{2-\frac{1}{2}\left(1-\frac{T_c}{T_h}\right)+\frac{2}{\underline{ZT}}\left(1+\frac{T_c}{T_h}\right)} \quad (9)$$

Finally, the total output power was calculated based on the number of modules connected in series as shown in equation 10. The max conversion efficiency was calculated using the figure of merit calculated earlier and inputting into equation 11. The heat absorbed was calculated by dividing the total output power "Wt" by the conversion efficiency "η_{mp}" as shown in equation 12.

$$W\mathrm{t} = (\#\ of\ modules)W_n \quad (10)$$

$$\eta_{max} = \left(1 - -\frac{T_c}{T_h}\right)\frac{\sqrt{1+\underline{ZT}}-1}{\sqrt{1+\underline{ZT}}+\frac{T_c}{T_h}} \quad (11)$$

$$Q_h = \frac{W\mathrm{t}}{\eta_{mp}} \quad (12)$$

It should be noted that due to the lack of certain data provided in the pdf file, certain variables such as the length and cross-sectional area could only be assumed. Thus, the data provided may vary from actual data after obtaining the TEG module and measuring the module precisely.

2.1 TEP1-12635-3.4 Calculated Values

$T_h = 573.15k$; $T_c = 303.15k$; $\alpha = 317.46\ \frac{\mu V}{k}$; $\rho = 4.941 \times 10^{-3}\Omega cm$; $\underline{ZT} = 0.596$;
$R = 0.043\Omega$; $I = 0.989A$; $V_n = 5.40V$; $W_n = 5.42W$; $\eta_{mp} = 6.8\%$;
$W\mathrm{t} = 37.94W$; $\eta_{max} = 6.9\%$; $Q_h = 557.94W$

2.2 TEG2-126LDT Calculated Values

Th=473.15k; Tc=303.15k; α=400.16 Vk; =3.73510-3cm; ZT=1.11;
R=0.05; I=0.68A; Vn=4.29V; Wn=2.92W; mp=7.5%;
Wt=26.28W; max=7.8%; Qh=350.4W

The result of the conversion efficiency and heat absorbed for both modules was compared. Upon obtaining the data in regards to the max temperature measured from the power supply, it was determined that both modules meet the criteria. The TEG2-126LDT module was chosen however due to its higher conversion efficiency compared to the TEP1-12635-3.4 module.

2.3 TEG2-126LDT Calculated Values using Measured Length and Cross-Sectional Area

$$T_h = 473.15k;\ T_c = 303.15k;\ \alpha = 400.16\ \frac{\mu V}{k};\ \rho = 3.735 \times 10^{-3}\Omega cm;\ Z\underline{T} = 1.11;$$
$$R = 0.043\Omega;\ I = 0.785A;\ V_n = 4.286V;\ W_n = 3.36W;\ \eta_{mp} = 5.3\%;$$
$$W\mathrm{t} = 23.52W;\ \eta_{max} = 5.4\%;\ Q_h = 435.55W$$

After obtaining the TEG2-126LDT Module, the length and cross-sectional area of the thermocouple were measured. This was done to update the calculated variables to obtain a precise value for the conversion efficiency and heat absorbed. The calculation process was repeated and it was shown that the conversion efficiency was lower than estimated due to the change in length and the cross-sectional area between estimated and measured value. However, due to the lack of variation in the value of voltage and current of the module itself, it was surmised that the result would not interfere with the schematic of the TEG device.

3.0 Temperature and Voltage Measurement of TEG Modules

For this section of the experiment, nine TEG modules were connected in series. A heat plate was used as a platform for this experiment where the hot side of the TEG device was facing towards the heat plate. The heat plate was set to 42.0 °C, due to this being the highest temperature reached by the power supply. Eight heat sinks were placed on the cold side of the TEG device to act as a clamping force as well as to saturate the heat being transferred through the TEG device. The room temperature was measured at 34.0 °C, before the start of the experiment. The temperature and voltage were measured in five minutes increments using a digital thermometer and multimeter respectively over one hour. The setup of the experiment was as shown in figure 3.

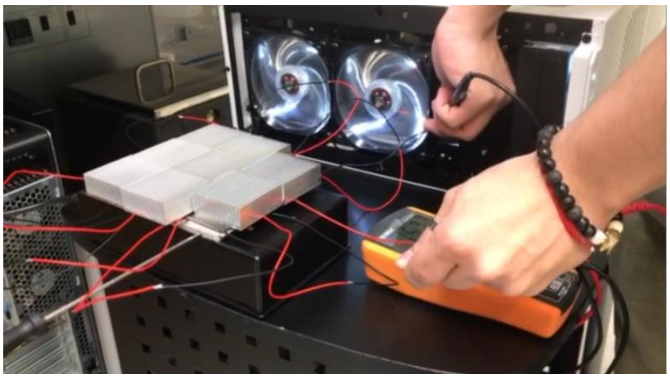

Figure 3: Temperature and Voltage Measurement

The scatter plot displayed in figure 4 represents the temperature changes and voltage output of nine TEG modules in series over approximately one hour. This graph corresponds with the data recorded as shown in table 4 located in the appendix. There was no deviation in the change in temperature for twenty minutes before the heat sinks became saturated with heat which resulted in the temperature of the two sides gradually reaching thermal equilibrium. The voltage output

was also shown to be above the 1.5 volts threshold over one hour, yet does not reach the minimum voltage required to power a computer fan. Due to this result, it was surmised that the TEG device would require a voltage boost converter from 1.5 volts to 5.0 volts to provide the necessary voltage needed to power a five-volt fan.

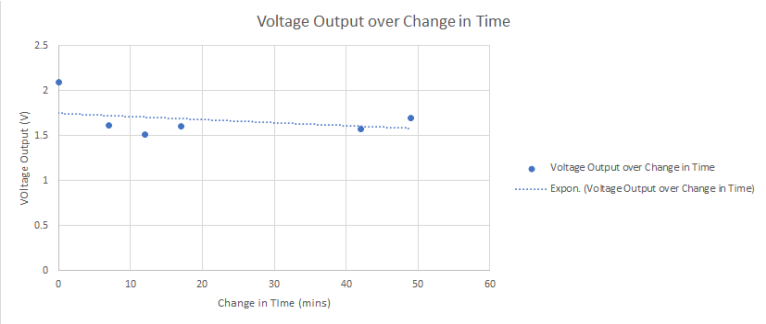

Figure 4:Trendline of Voltage over Time for Nine Series TEG Modules

4.0 Testing the 1.5 Volts to 5.0 Volts Boost Converter on 5 Volt fans

Using the information obtained from temperature and voltage measurements, a voltage convertor was used in conjunction with a charged battery. The battery is used to jump-start the TEG system. The idea is to have a duo battery system connected with the TEG set up so that the TEG device will charge one of the batteries while the other battery is used to provide power to the five-volt fans. After soldering two sets of positive and negative charged wires on the voltage converter circuit, the circuit was connected to the 5-volt fans. During the testing phase, it was concluded from video recordings that the voltage converter can only power a single 5-volt fan if two 5 volt fans are connected in series, whereas the voltage converter can power two 5-volt fans if they are both connected in a parallel circuit at the expense of a higher amperage requirement. Figure 5 and Figure 6 show the connection of a 1.5-volt to 5-volt boost converter on two 5-volt fans in series and parallel.

Figure 5: Volt Converter on fans in Series

Figure 6: Volt Converter on fans in Parallel

4.1 Temperature Measurement of Power Supply

For this section of the experiment, the temperature located at the hot zone of the power supply was measured using a temperature probe. Based on the recorded temperature sets recorded for the power supply, the average temperature was calculated on the power supply and its relation was graphed. T1 was measured at the center of the top plate of the power supply, T2 was

measured at the top left of the top plate of the power supply, and T3 was measured at the center-right of the top plate of the power supply. A CS: GO practice match was conducted every 10 minutes for a total of 100 minutes of run time. This is to ensure that the temperature of the power supply reaches a steady-state before conducting a temperature measurement.

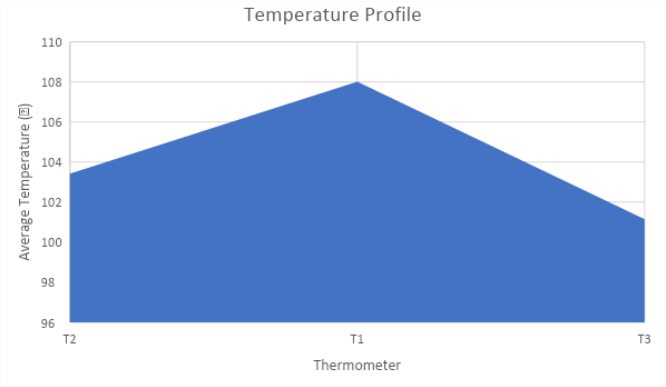

Figure 7: Temperature Profile at Three Different Measuring Locations

Based on the temperature profile shown in figure 7, the highest temperature measured was 106°F, which is approximately 41.11 °C. This is believed to be the highest temperature that can be achieved through light CPU-intensive gaming. The highest average temperature calculated was 102.33°F, which is approximately 39.07 °C. This is believed to be due to certain spots on the power supply having a harder time absorbing heat, thus creating uneven heat flow which resulted in a lower temperature average. It can be concluded based on observation of the temperature profile that the heat that will be used to power the TEGs will need to be mainly gathered from/to the center to create the best possible temperature difference. It should be noted that the power supply takes approximately 2 hours to reach a steady state which might affect the efficiency of our TEGs early on.

TEG Schematic Device

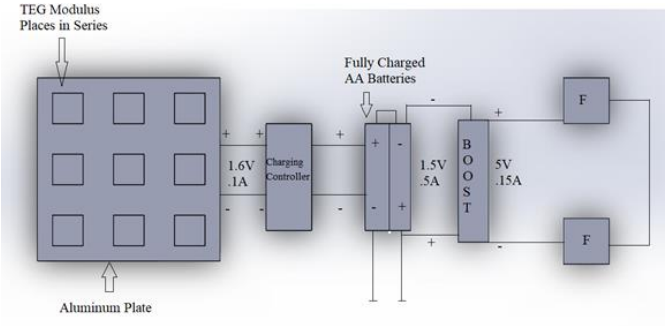

Figure 8: TEG Device Schematic with Duo Battery System

The diagram representing figure 8 above serves as a representation of the electrical system of the thermoelectric device. There will be nine TEG modules connected in series on top of an aluminum plate, which would then be placed above the case that would overlay the power supply. The TEG modules would then be connected to a charging controller that would regulate the charge rate towards the empty battery. Meanwhile, a fully charged battery would be connected to a 1.5 volt to 5.0-volt boost converter, which would then provide power towards the

two 5 volt fans connected in parallel. The concept is to have a duo battery system where one of the batteries is charged at all times to continuously provide power towards the two 5 volt fans.

5.0 Design

5.1 Design Focus

The overall focus of these concept designs was the magnification of the Seebeck effect to increase the energy conversion of the TEGs. After some calculations were made about the theoretical output of the TEG's and some thermal analyses were done to the computer setup. We decided to implement other technologies aimed toward favorably altering the thermal properties of the system compared to alternative designs explored in previous years.

5.2 Design Concept

The final product design concept includes the use of an aluminum plate as the hot side for the TEGs. The plate was placed over the top side of the power supply taking direct advantage of the hot zone. To address the possibility of uneven heating provided by the power supply, additional heat would be gathered from other faces and directed into these uneven thermal locations via copper wires (currently this modification is only a concept due to time constraints). The power supply case was created to safely elevate the power supply's overall temperatures without the use of thermal insulation or thermal epoxy to attach other components to the power supply. In addition to providing structural support (the case is fixed to the computer case via M3 screws) and is attached via the same holes used to secure the power supply in the back face and vertical screw holes in the front face.) plus a clamping force for the aluminum plate and copper wires to ensure optimal heat exchange between the components and the power supply.

The case is expected to be 3D printed during the following week of prototype testing to evaluate the actual increment in temperature and its associated effects on the energy conversion. This safe increment in temperature will be achieved by using PLA for the printing material. Whose material thermal resistance is not particularly high (referenced by the research paper on PLA material properties by MIT) proving a good candidate for the component's purpose. To make this final product design into a workable prototype a few adjustments were made. This includes notable modifications to the aluminum plate and placements of TEGs. A representation of this design concept is shown in figure 10.

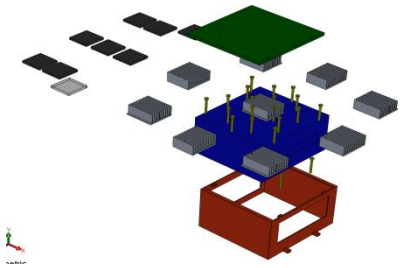

Figure 9: Exploded View Concept Assembly

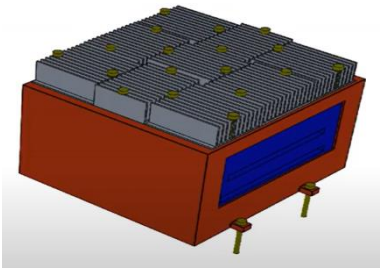

Figure 10: TEG Device Concept Assembly

Aluminum plate and TEG configuration

The initial assumption for the aluminum plate and TEG configuration was the dimensions of the power supply and the utilization of 7 TEG modules based on the geometric constraints of the

computer case and theoretical analysis of the TEGs power output. The final iteration of the aluminum plate accounted for the live testing done with the TEGs seen in figure 11 where the addition of two TEG modules for a total of nine modules was made. Minor adjustments to the aluminum plate size were done, and support holes were also replaced to create a compact design. These changes were motivated to allow for more space for the TEG's as well as size-varying versions of the aluminum heat sinks were made for the same purpose. The new heat sink orientation/placement still kept the appropriate distance between TEGs allowing for the proper mounting of the modules (referenced in the installation guide of the TEGs.).

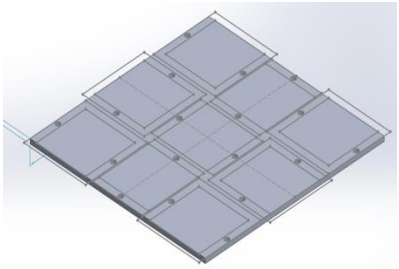

Figure 11: CAD Model of 9 TEG module Placement with a heat sink on Aluminum Plate

5.3 Bolt Design

Given the installation guide requirement of a specific clamping force to act upon each TEG module to provide enough surface contact for the listed energy conversion efficiency, a bolt was designed based on the suggested values of the guide and in the reference textbook which became our constraints and requirements (Factor of safety/ design factor: 2). The known variables were the Preload/Live Load of 2256.3N, a screw nominal diameter of 4mm, and a suggested Preload Torque of 1.25568N.m. Further research (types of bolts can be seen in figure 8-10 in the Shigley's Textbook on page 423) done on the various bolt types and based on availability constraints the type of Bolt chosen for the design was Socket Head Screw Cap. The material readily available during the time of the design process was Steel and is what we considered for our bolt design.

Based on what we were given, the bolt design found the following variables and their values:
***Pitch*:** According to Table 8-1 on Page 412 of the reference textbook "Shigley's Mechanical Engineering Design" based on the nominal major diameter given to be 4mm. The pitch is equal to 0.7mm for a coarse pitch (the selected pitch type) or 0.5mm for a fine pitch based on reference from Company "Bayou City Bolt". The coarse pitch was selected for being less prone to cross-threading and is a better selection for a clamping force.
***Pitch diameter*:** was calculated to be 3.55mm and the minor diameter is 3.14mm based on the equation shown on mechanical.com. Where "P" is the bolt pitch, d-nom is nominal diameter, dm is minor diameter, and dp is pitch diameter.

$$d_{m,ext} = d_{nom} - 1.226869 \times P \quad (13)$$

$$d_{p,ext} = d_{nom} - 0.75 \times H = d_{nom} - 0.64951905 \times P \quad (14)$$

***Bolt length*:** Based on the grip (including no washers) that would be clamped by the bolt measured to be approximately 10.78mm on SolidWorks (Figure 25). The bolt length would be

the grip plus about 3mm of additional length based on the nut thickness for a total of 13.78mm (distance between the top face of the heatsink to the bottom face of the aluminum plate). The minimum thread length for this bolt would be (Lt) would be 14mm based on metric bolt standards (equation below used to calculate).

$$L_t = 2d + 6 \quad (15)$$

***Nut thickness*:** the type of nut that will be used an injunction to the designed bolt will be an M4 nut with a thickness of 3.2mm based on Table A-31 in the textbook, as well as "Standard Metric Hex Nuts per ANSI/ASME B18.2.4.1M and B18.2.4.2M" by engineersedge.com.

***Bolt head thickness*:** according to ASME B18.6.7M, Table 14, "Dimensions of Hex Head Machine Screws." The standard thickness for this bolt head is 3mm. This gives us a good estimate of what to expect for the socket head screw cap.
***Nut and bolt head width*:** based on the same table used to find nut thickness. The width would be at a maximum of 7mm or 8.08mm measured corner to corner.
Based on Table 8-11 on page 435 in the reference textbook, a Property Class: 8.8 was chosen primarily to satisfy the design factor (nd) placed for the bolt. The material property of interest of this property class is proof strength (Sp = 600MPa), Material: medium carbon, Q&T steel.

$$\sigma_i = \frac{F_i}{A_t} \quad (16)$$

$$\sigma_i = \frac{F_i}{A_t} = \frac{S_p}{n_d} \quad (17)$$

$$2 \leq 2.33$$

***Minimum Clearance Hole*:** Based on ASME B18.2.3.1M shown on an adapted table on mechanicalc.com for an M4 bolt would be 4.3mm (tight fit). This is reflected in various figures (Figure 24, 18d, 18c, 18b, and 18a)
***Final decision*:** was made to buy M4 X 07, Grade 12.9 bolts (16mm) and nuts modeled and shown in Figures 19 & 20. These figures describe the off-the-shelf features of the purchased components.

6.0 Analysis & Results

Based on the various parts and their respective material properties a study was done to observe the effects the clamping force has on the TEG assembly. A finite element analysis study was conducted as shown in figure 12 the conditions of this study were the applied force of 2257N at each nut and bolt connections and a fixed bottom face of the aluminum plate.

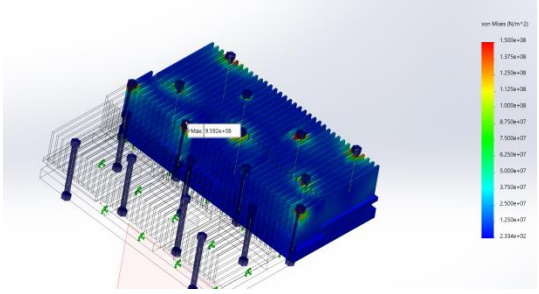

Figure 12: FEA Static Analysis with a loading condition of 2257N Axial Force Preload and Fix condition at the bottom face of the plate.

The results of the FEA static analysis represent a close representation of the stress concentration that would occur if the bolts were applied directly to the fins of the heat sinks. The majority of the high-stress values (1e+08 - 1.5e+08) can be observed around the contact zone between the fins and the bolt. The conclusion taken was that the bolt needed to be placed in a portion of the heat sink base to distribute the stress over a larger area.

An additional conduction analysis was done based on Fourier's conduction equation on a 40mmx40mm area to understand the effects of using thermal paste, pads, and glue.

Using the equations below the thermal resistance and energy released by conduction was calculated:

$$q = A * \frac{\Delta T}{\Sigma R_{TH}} \quad (16)$$

$$R = \frac{\Delta x}{k} \quad (17)$$

Here the "A" stands for the cross-sectional area of the surface perpendicular to the heat flow, "x" is the thickness of the layer, "k" is the thermal conductivity of the material used, and "R" is the thermal resistance of each member.

The results shown below reflect each member's thermal resistance where among the thermal compounds used in the product the thermal pad offered the worst resistance from every member. The thermal glue on the other hand offered the second lowest resistance behind the thermal paste. This means that the use of this thermal glue offers higher benefits rather than hinder efficiency. Finally, the heat reaction of this conduction analysis was found to be exothermic showing how much heat is lost in the process of moving from the power supply up to the heat sink.

$$q = -2.879kW; \quad A = 1.6 * 10^{-3}m^2$$

$$R_{a3003} = 3.529 * 10^{-6}m^2\frac{K}{W}, R_{a30032} = 3.735 * 10^{-5}m^2\frac{K}{W}$$

$$R_{Gr} = 3.232 * 10^{-5}m^2\frac{K}{W}, R_{a6061} = 1.765 * 10^{-5}m^2\frac{K}{W}$$

$$R_{TP} = 1.538 * 10^{-7}m^2\frac{K}{W}, R_{TG} = 1.026 * 10^{-6}m^2\frac{K}{W}$$

$$R_{TPad} = 6.25 * 10^{-5}m^2\frac{K}{W}$$

$$R_{TH} = 1.545 * 10^{-4}m^2\frac{K}{W}$$

7.0 Final Cost of Project

After all of the parts and components were purchased, the total cost of the project was $808.36. The detailed breakdown of all equipment purchased for this project is provided in table 2.

Table 2: Purchased Equipment

Equipment	Number of Units
Fractal Design Focus G Mid-Tower Case (White)	**1**
Step up Converter Regulator	**1**
Seasonic - FOCUS GX-750, 750W 80+ Gold PSU	**1**
TEG2-126LDT Scavenger TEG module	**9**
Digital 2 Channels K-Type Thermometer	**1**
Tenma Multi-meter	**1**
Power-Spec Computer G157	**1**
Aluminum Heatsink 50mm x 50mm x 20mm	**2**
Easy cargo 2pcs Silver Tone Heatsink 50x50x20mm, Aluminum Cooler Cooling Heat Sink (50mmx50mmx20mm)	**2**
Noctua NF - F12 5V, Premium Quiet Fan with USB Power Adaptor Cable, 3 Pin, 5V Version (120mm, Brown)	**2**
Thermal Grease Paste	**1**
Thermal Grizzly Minus Pad	**3**
Aluminum Sheet, HAKZEON 2PCS Premium 3003 Aluminum Sheet Metal 6 x 12 x 1/4 Inch Thickness Rectangle Metal Plate Covered with Protective Film Heat Treatable Aluminum Sheets for Crafting	**2**
18650 Battery Case Holder with Lead Wire Bundle, 4 Pcs DIY Battery Storage Boxes, 1 Slot, 2 Slots, 3 Slots, 4 Slots Black Plastic Batteries Case with Pin	**1**
Comidox 1.5V 1.8V 2.5V 3V 3.3V 3.7V 4.2V to 5V DC -DC Step Up Power Module Voltage Boost Converter Board 0.9 -5V to 5V	**1**
D Cell Batteries - USB Rechargeable Lithium D Batteries - 1.5V / 4000mAh (2-Pack)	**2**

8.0 Discussion of Future Work

Future steps are prototype testing as additional testing is conducted, the final steps for this project will be prototype evaluation and results/ final thoughts to analyze our results to determine improvements in terms of safety and efficiency as technology evolves. A final report will be created to document and explain the results. This will be achieved by reporting on the temperature to the voltage output of the assembled prototype and doing an additional FEA analysis and thermal study to monitor abnormalities around critical locations in our design.

9.0 Conclusion

Converting renewable energy has been increasing in recent years and by doing so, this should reduce the reliance on non-renewable resources that are considered harmful to the earth's environment. While conducting research, it was shown that a thermoelectric generator is a device that can reuse the heat generated from a desktop computer that would otherwise be wasted. All aspects of this project have focused on creating a concept design stressing the reliability and effectiveness. The estimated cost for this project was calculated to be $265.26. The development of this device will further expand the use of renewable energy in the electronics industry by being affordable enough for the average-income household to have access.

10.0 Acknowledgment

As a group, we would like to acknowledge Dr. Rahemi, Dr. Elzawawy, and the Vaughn College of Aeronautics and Technology department of engineering faculty for their technical support. Also, a special acknowledgment to the HSI-STEM title III and CSTEP program for funding and supporting this project.

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Wireless Heating Pad

CSTEP Research Program

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Abstract

Heating pads are used in therapeutic settings for medical purposes and the alleviation of pain. When heat is applied to the skin, blood vessels dilate, increasing the blood flow, and provide oxygen and nutrients to aid in the healing of strained tissue. The ability to apply heat to an affected area, when needed, is a necessity many take for granted and which even more do not have. The electric heating pad has become more efficient, safe, and user-friendly over the years, but the team's goal is to innovate this product by introducing a wireless connection to make the device more efficient, lighter, and portable. The objective is to reduce harmful biological effects on users, while also making the device cost-effective. This paper will demonstrate and discuss the design of the wireless heating pad, safety measures, and the electric components.

1. Introduction

The concept of heating pads was introduced in the beginning of the 20th century by Doctor Sidney Russel. Applied heat to affected areas was an effective form of therapy, even in prehistoric times. Warmth is synonymous with comfort and relaxation, but heat therapy has reformed its applications and can provide both pain relief and many healing benefits [1]**.** Heat therapy is currently provided instantly and inexpensively using wired heating pads, commonly found in households. There is still room for improvement of these devices, and the need to make these pads more accessible and portable is growing [2].

The familiar heating pad presents two main concerns. The first is the electric and magnetic fields (EMF) exposure. This is a result of the current flow through the wires that simultaneously increases with the amperes provided. This exposure to radiation is believed to enhance the risk of being diagnosed with cancer, infertility, or pregnancy problems [3]. The second issue currently known about heating pads is the danger of fire. With the wires conducting heat so close together, all it takes is for one of them to become crimped or frayed to cause a life-threatening accident. Individuals over the age of 66 have been critically burned, and they comprise 89% of

the deaths due to electric-blanket incidents [4]. Those diagnosed with diabetic neuropathy have reduced sensation in the extremities, a characteristic which prevents them from knowing when a pad has overheated [5].

Electro-magnetic fields (EMFs) can be subdivided into two categories, ionizing and non-ionizing. When current flows through a circuit, an EMF is produced whose direction can be understood via the "right-hand rule". Being exposed to ionizing radiation "can be harmful because it can break chemical bonds and change the molecular and chemical structures of various substances, including human tissue. Overall, a person is more likely to experience damage if they are exposed to high levels of radiation over a longer period" [6]. Non-ionizing fields are found in common places (natural and manufactured), and exposure to it is not necessarily harmful to the human body. The solution to counteract EMF effects is to place the wire in parallel for the fields to cancel each other, and to use material which is not a great conductor, yet is efficient in providing heat to the blanket carbon fiber.

Overheating has been the main problem resulting from improper use of heating blankets. Many reports display cases of death, injury, or fire [7]. A resolution to this problem was brainstormed by the group to be the use of a microcontroller (Arduino) and electric components (thermocouple and MAX6675) to decrease these potential hazards. This innovation was intended to improve the working function of heating blankets, while providing the most safe and comfortable way to address user's needs.

The team's proposal is to implement a remote/wireless control technology for higher portability, along with temperature sensors controlled by Arduino to decrease the safety hazards of the innovated heating blanket. The goal of this project is to improve the function of modern heating blankets, while protecting consumers from any hazardous consequences resulting from malfunctions.

2. Impacts

2.1 Social Impact

This heating blanket will have an impact on global societies. This product will play an important role in determining the future of wireless heat therapy. Several social factors can be considered as significant, but the most important impact will be education. One must think about those who are most in need of heating blankets and those who benefit the most. These people are the hospital patients, those who live in cold climates, and those whose bodies endure the worst conditions (whether biologically or environmentally). Providing these individuals with the capability of a heat source when they need it the most, while doing so with maximum efficiency, is the foremost goal. The wireless technology implemented into this heating pad will give those who truly need it the chance to use this device, even in the most difficult situations.

In February 2021, Texas was hit with the one of the worst winter storms. A record number of people lost power, heat, and water for days. "At the height of the crisis, nearly 4.5 million Texas homes and businesses were without power." [8]. In a release, the agency stated "The majority of storm-related deaths verified to this point were associated with hypothermia," [9]. A portable, wireless, heating source could have made a difference in keeping these people alive. Having access to heat, even without power, can make a huge practical difference in people's lives.

2.2 Environmental Impact

There are several environmental impacts the wireless heating blanket provides: portability, energy efficiency, warmth uniformity, and temperature control, to name a few. Making devices portable creates ease for users, and this wireless heating blanket allows for one to move effortlessly from one location to the next. Using the electric blanket would be more effective than using a space heater which plugs into a wall, uses more wattage, and limits mobility [2]. By maximizing the amount of energy from the battery source and utilizing sustainable components, we can provide a higher energy efficiency, which positively affects the environment. Carbon fiber heating is important in saving energy resources. With its dynamic management, it can heighten the energy conversion rate to reduce the cost of a project. It reduces waste on electricity, water, heat, and similar energy resources. [15].

2.3 Economic Impact

Several countries are witnessing a compound annual growth rate (CAGR) in the marketing of electric heating blankets and are prospecting growth between 2020-2027. America, Canada, and several East Asian Countries are witnessing this growth, amidst the pandemic, which has caused people to stay home more often than before. "Amid the COVID-19 crisis, the global market for Electric Blankets estimated at US $779.8 Million in the year 2020, is projected to reach a revised size of US $1.2 Billion by 2027, growing at a CAGR of 5.9% over the analysis period 2020-2027" [10]. Overall, the economy witnessing the highest prospects in growth is China; this fact provides insight into which regions the wireless heating/cooling blanket can be marketed and advertised.

3. Procedure & Safety

The production of a safe, cordless, and accessible heating pad for consumers, that is also committed to product comfort, safety, and innovation was our goal. To ensure comfort while allowing efficiency and accessibility, the 1 pound, 9.5 x12 inches pad will be made of plush micro polyester, making it wearable on any body part.

- **Wire and Fabric**

An assembly of 8 m of carbon fiber wire will be distributed to create a current and generate heat throughout the pad. This wire is radiation-free, energy saving and has long life. The advantages of using carbon fiber wire are the high conversion efficiency, which in turn optimizes the heat transfer. It also provides the product with the flexibility and mobility features it needs to be wrapped and molded around any body part. Carbon fiber is naturally light and extremely flexible in its natural state. Once it's combined with a resin and shaped in a mold, it becomes lightweight, ten times stronger, and much more flexible [16]. The placement of the wire in the pad is precisely in parallel to eliminate any possibility of EMFs and to provide efficient heat. The wire will be sandwiched between two layers, 3) and 5) from Figure 1. Layer 3 will be composed of a thermolam fabric which is also 100% polyester and will aid in keeping the heat from escaping, along with concentrating it to a fixed downwards position. The other surface of the carbon fiber wire will be exposed to layer 5, which is a reflective insulating layer that will protect the user from burning. This is the surface of the pad that will be directly applied to the skin. Finally, this will all be wrapped in the micro polyester which will allow for a soft touch and comfort for the user.

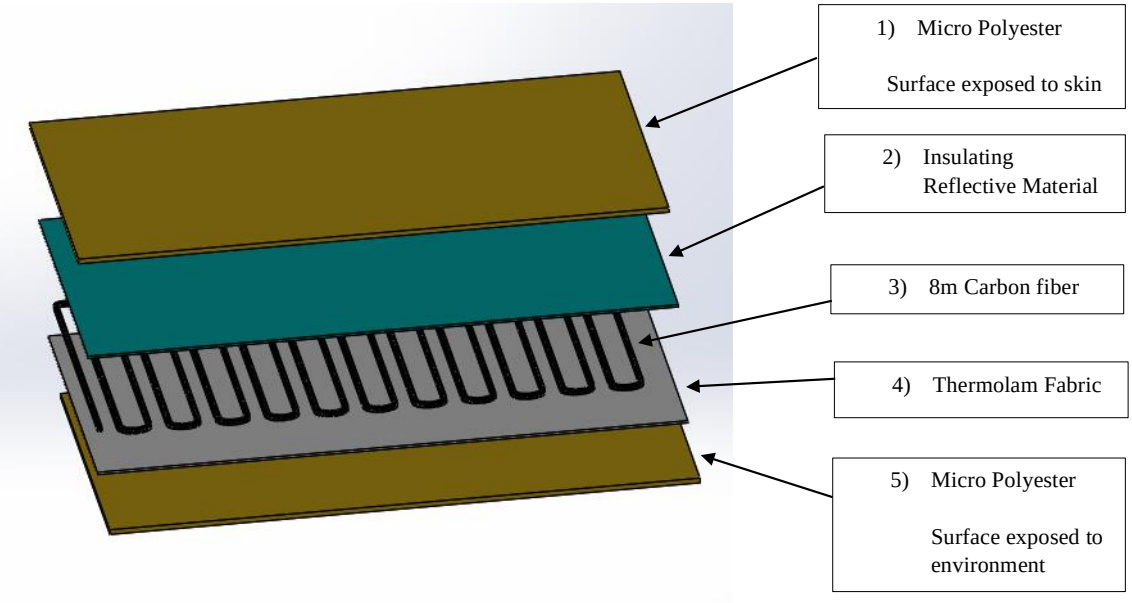


Figure 1: SolidWorks design of heating pad layers

- ***The Encoder***

Finally, to make this device wireless, an encoder that serves as a remote-control receiver will be installed within the same 8-ounce compartment as the rechargeable lithium-ion battery. The wireless module will be the intermediate communicator between the sensors and the Arduinos. The heat transfer from the pad to the body can be prevented, and the temperature of the pad will increase if the heat is trapped. Having these sensors and wireless control helps to eliminate the hazards of the device and to provide safe technology.

- **Thermocouples**

To prevent fire hazards, the pad will implement thermocouples, MAX6675 module and an encoder to shut off before overheating. Adding sensors increases the safety and performance. It will also monitor the temperature of the body compared to the temperature of the pad, and set the temperature to a voltage limit (temperature limit) through an Arduino. Using a thermal resistor, the change in temperature while the voltage is being distributed throughout will be measured.

- **Battery**

A 5 x 3 x 3 inch compact battery pack will be designed with an implemented flat rechargeable lithium-ion battery than can last for four hours of performance. The battery would have a port that connects with the outer side of the pad for ease with battery charging. The battery source will also be connected to different sensors, such as the thermistor, and Arduino for programming and developing. The power source will have a foam material to help reduce the amount of heat coming into the battery to prevent any short circuits or possible damage.

- **Safety Standards**

Manufacturers in the US who want to create a heating pad must follow the UL 130 Standards for Electric Heating Pads [1]. These standards present the basic rules and tags that must be labeled for every customer who wishes to purchase a heating pad. The biggest hazard noted about heating pads is the possibility of causing harm to the skin or of use while unconscious. According to the UL 130, the maximum allowable temperature on a heating pad must be kept below $194°F$ $(90°C)$. An additional required safety feature is having a "Dead Man Control" system in place, in case the user keeps the heating pad on for an extended period. To meet this requirement, the team implemented an internal timer, where every 15 minutes, the pad will begin cooling down and turning off unless otherwise instructed by the user. Warnings would, of course, be attached letting the user know about the dangers of having extended exposure to heat on the skin ,even in low temperature mode.

4. Design and Analysis

4.1 Electrical Engineering

Inside the heating pad, the Arduino controls the system's process of communicating the rotary encoder – featured on the pad's controller – to the heating pad, and decodes the user's desired temperature setting. From there, the Arduino sets the desired temperature to match the real temperature value of the heating element, through PID control.

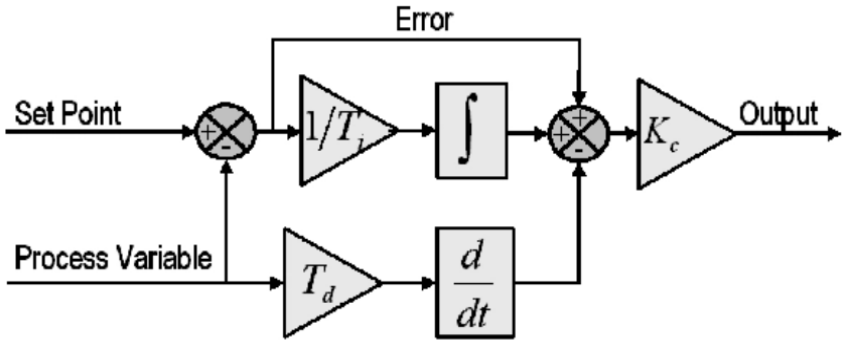


Figure 2: Illustration of the PID controller considering the set point, error and process variable, and its relation to the proportional, integral, and derivative constant

PID Theory – The proportional gain (K_c) determines the ratio of output response to the error signal. Although increasing this ratio increases the speed of the control systems response, it ultimately causes large oscillations that cause instability in the system. The integral component sums the error over time. This continually increases while the setpoint and the process variable are different. The objective of this response is to drive the Steady-State error to zero, which is the final difference between the process variable and set point. Finally, the derivative component causes the output to decrease, if the process variable is increasing rapidly. This response is proportional to the rate of change of the process variable. Increasing the derivative time (T_d) parameter will cause the control system to react more strongly to changes in the error term, and will increase the speed of the overall control system response, but considering the response

is sensitive to noise in the process signal, easily causing instability, it is best to leave a small derivative time. [12]

The electrical design of the heating pad consists of four subcircuits: the pulse width modulation circuit (PWM) that feeds the heating element with ranging voltages; the rotary encoder that communicates the desired temperature to the microcontroller; and the MAX6675 module that enables the microcontroller to communicate with the thermocouple – feedback of the system. The circuit is the design of the heating pad prior to adding the radios to make the setting component – the rotary encoder – communicate wirelessly with the microcontroller.

The software used to illustrate those subcircuits is Fritzing for circuit design (Fig. 3). The first subcircuit, Fig. 3-(1), consists of an S8050 transistor (NPN), an IRFZ44N MOSFET, and 10 kΩ resistors. The transistor is implemented for amplification purposes as it has a maximum gain value of 400, while the PWM signal is applied to the MOSFET that controls the voltage going into the heating element. The voltage applied to the element is directly related to the quantity of the error given by the PID controller. If the real value is higher than the desired, the power is lower, while if the real value is lower than the desired, more power is applied. This subcircuit is connected to a voltage source of 12 direct current (DC) volts, although the power going through the circuit is rarely equivalent to the input.

The second subcircuit, Fig. 3-(2), consists of the rotary encoder communication. This encoder has five pinouts, from which three communicate to the Arduino. These pinouts are established as: SW - the active low push button switch output; CLK or output A – primary output pulse to determine the rotation; and DT or output B - an output pulse that lags the CLK by a 90-degree phase shift. As the encoder does not provide any resistance value, 10 kΩ resistors are added to the pin connections mentioned to control and decrease the current going into the Arduino, particularly in the case when the first subcircuit sends a high voltage to the hardware.

The third subcircuit, Fig. 3-(3), implements the MAX6675, thermocouple-to-digital converter, module. The module consists of eight pinouts, from which three are connected to the Arduino, while the other two are connected to the thermocouple. The pinouts that are connected are as follows: SCK – serial clock output; CS – chip select, which is set as low to enable the interface; and SO – serial data output. As the module functions as the feedback while it records the real value of the temperature, no resistors are required to keep to decreases current or voltage going through the circuit.

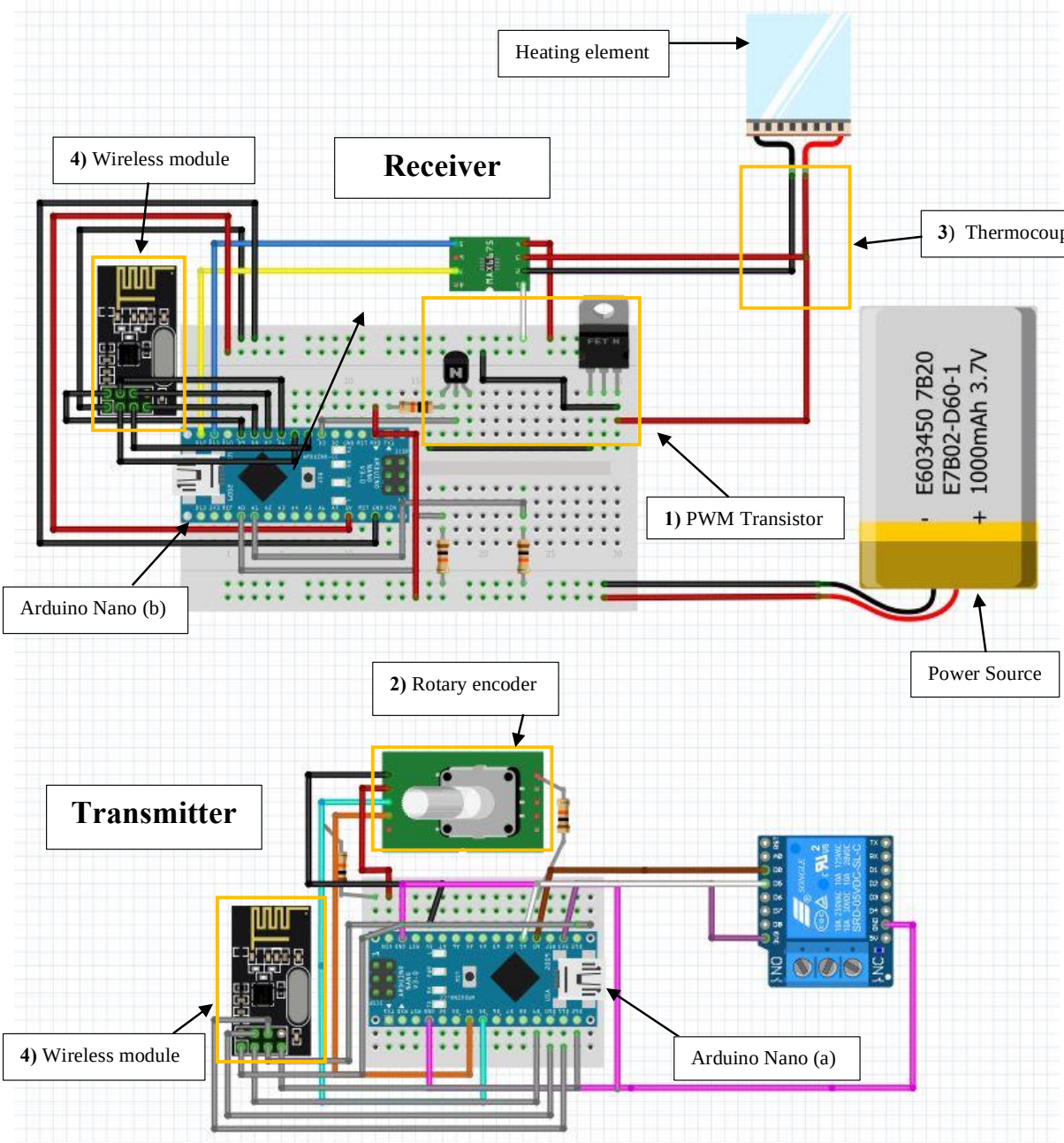
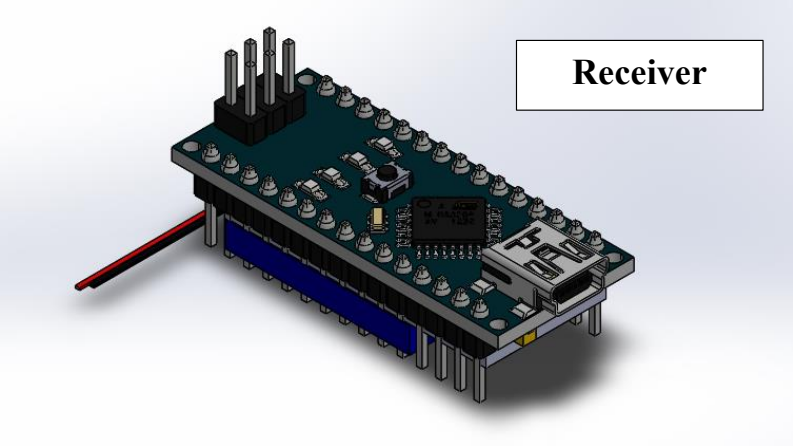


Figure 3: Complete circuit design: the controller and the Arduino in the pad including the wireless module, the power source, and the PWM transistor

The fourth subcircuit, Fig. 3-(4), implements the nRF-24L01 wireless module. This component will communicate between the Arduino nanos to perform tasks given in the code. Instead of manually inserting a cable connecting the board to the heating pad to perform the task, it will connect via waveform from an antenna to a receiver. The receiver will decode the data being transmitted to turn on the heating pad along with the rotary encoder and thermocouple module to control the temperature.



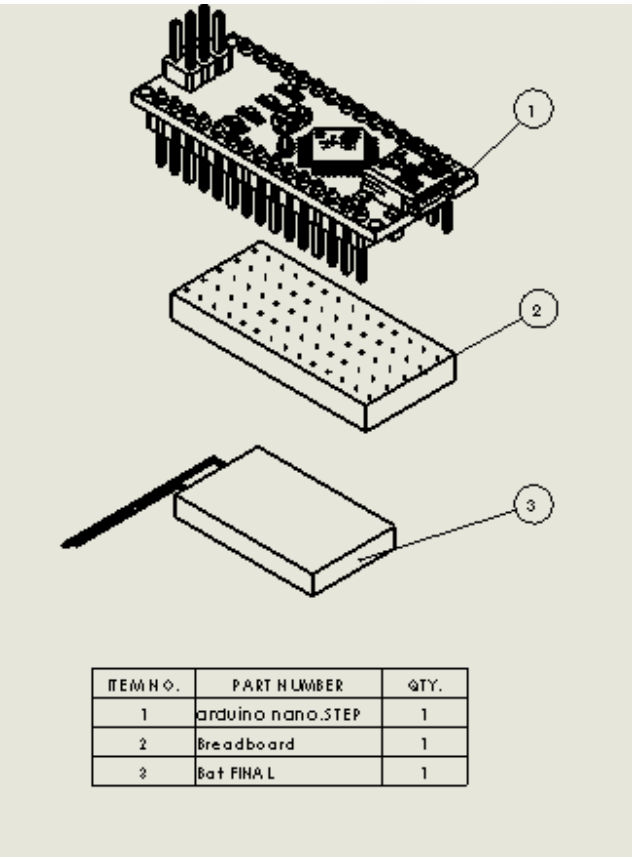


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Figure 4: SolidWorks design for the compact Receiver. Isometric and explode assembly drawing

4.2 Coding and Temperature Control

The Arduino interface development environment (IDE) is implemented for the heating pad to obtain the desired characteristics: temperature controller, shutdown function to ensure user safety, and wireless control. The PID setting are established in the loop of the Arduino code (C++) and are dependent upon the "menu activated" input which corresponds to the push button signal (SW) from the rotary encoder. Interrupts are implemented to stop the regular execution of the code and can be generated inside or outside of the microcontroller. [12]

An external interrupt is used to stop the program for the user to set their desired temperature. Once the desired value is stored in a variable, the program runs again until another interrupt signal is recorded. This ISR recognizes that the push button on the encoder was pressed a number of times and executes a process for each. For example, if the button is pressed once the program begins to run, it detects the rotational direction the user is rotating the encoder to set the temperature and the countdown function. This is a safety configuration to ensure that the user will not get burned. This function is timed to decrease the temperature after 15 minutes of being at the highest temperature setting. Each part performs different tasks depending on which Arduino is transmitting or receiving data.

The team designed the pad to function this way to fully provide the heating pad with wireless capabilities and communicate the functions defined for the thermoscope, the PID and other sensors put together. Arduino (a) in Fig 3, is connected to the rotary controller and is in a separate casing. Each pin is defined with 2 settings attached for low and high. The RF24 module transmits the code on a specific frequency level and tells Arduino (b) any simple functions the user would like to do such as raise the temperature or turn on the device. On the right side, the receiver module will interpret the data that was transmitted by the main Arduino within the controller. If a certain "tempState" is met, then the Arduino within the heating pad will begin the voltage circulation, heating up to a specific voltage, unless otherwise told.

4.3 Heat Transfer Analysis

The purpose of using SolidWorks for the heat analysis was to illustrate the distribution of heat through the pad with the initial boundary conditions. The thermal properties for each material in Fig. 1 were created to better model the system. The micro polyester which covers the whole pad has a conductivity of 140 W/mK, the carbon fiber wire has a thermal conductivity of roughly 40 W/mK, the Thermolam fabric and the reflective insulating material have 0.033 W/mK and 0.2256 W/mK, respectively. Each face of the pad was set to the initial condition, where they are exposed to the environment at room temperature, 23℃ (70℉). The carbon fiber wire was set to a temperature of 71.11℃ (160℉), which is the max temperature the wiring can reach to provide heat to this system. SolidWorks analysis helped to model the distribution of the heat and plot the relationship between the hottest and coolest temperatures.

We also wanted to calculate the rate of heat transfer during the estimated time the heating pad can operate. By considering the entire heating pad, including all the components, as one control system, and neglecting any friction or heat loss:

$$\dot{q} = \frac{\dot{Q}}{A}$$

$$\dot{q} = \frac{24.42\ Wh}{0.0735\ m^2}$$

$$\dot{q} = 332.06\ \frac{W}{m^2}\ per\ hour$$

Where $\dot{Q}$ is the heat transfer rate, A is the cross-sectional area of the surface the heat transfer is taking place upon, and $\dot{q}$ is the heat flux. The area of the pad is 0.0735 m^2 and the amount of

heat dissipated by the battery is 24.42 Wh (Watt hour). Thus, the heat flux on the surface of the pad is 332.06 $\frac{W}{m^2}$ per hour. At that rate, the battery source will have produced 1.328 kJ in 4 hours at the lowest temperature setting.

5. Results and Discussion

It is necessary to note that this report for the "Wireless Heating Pad" serves as a detailed analysis of the conceptual design of the team's product. Considering the stipulated hazards of the original heating pad, the team decided to focus on making the design user friendly, portable, and safe. The design was made user friendly by incorporating a PID controller that offers high priority to the user's command, which is to change the temperature setting. For this first objective, the team intends to replace the Arduino UNO for a nano Arduino. This hardware is incorporated within the pad and decreases the number of components off the breadboard, decreasing the heat transfer within the Arduino compartment and the weight of the pad.

For the second objective, the pad was made as compact as possible to allow the user to take the device on the go, while additionally adding a wireless controller with two temperature settings to make the device manageable for users of all ages. As such, it ultimately increases user satisfaction. The last objective was achieved by incorporating a short function that was activated once the user set the heating pad to the highest temperature of 71.11°C (160°F) to decrease the temperature to 23°C (73.4°F). The goal of the function was to decrease burn hazards upon exposure to high temperature for elderly and diabetic users. As expected, the team achieved the main goals of the product. Nevertheless, some of the original implementation ideas for the pad were discarded.

Initially, the team had proposed to use transformers to work alongside a timer that would shut down the pad after a stipulated time. This led the team to research timers for the ATmega328 microcontroller but branch off to search for countdown functions alone to decrease the number of components in the Arduino compartment. Finding the electrical design and example codes of automatic shutdown projects was not an easy task to complete. Furthermore, adding and modifying the current design to achieve the auto shut off was not successful, as most projects required a transistor, which would then leave the Arduino controlling another digital pin, which could not fit into the design. Changing to a Mega Arduino was not an option as it would make the device heavier. As a result, the last resort was to add a countdown function that would be enabled as soon as the user set the pad to its highest temperature. This contained a count variable that would loop while the setting was chosen, and upon reaching 900 counts, equivalent to 15 minutes, the temperature decreased to 23°C (73.4°F). This would alert the user to change the temperature setting.

At the lowest temperature setting, the 8m of carbon fiber wire can operate for a maximum of 4 hours before a need to recharge the battery. Our goal is to examine the heat transfer from the power source through each layer and finally to the skin. SolidWorks was deployed to help determine the autonomy of the system and to be able to read the temperature on the surface that will be applied to the body, at steady state conditions. Furthermore, use of suitable software to refine heat transfer analysis would be a great option to quantify the efficiency of the heating pad. COMSOL is the appropriate tool for that matter and will be considered for future work.

6. Conclusion

The team was able to bring together several ideas, designs, and research evidence to help innovate and pave wave for new ideas in consumer products. The carbon fiber wire will be one of the advantages of this wireless heating pad. Carbon fiber is temperature tolerant to excessive heat which will set it apart from the standard pad one would see on the market today. Its low thermal expansion and flexibility optimizes the heat transfer and makes it portable for travel.

Additionally, programming this device with Arduino is unlike the existing standard pads. The control system and software component allow for better temperature readings to prevent burning and adjustable time controls. The team added 5 subscripts control within the heating pad with two Arduinos that control two separate features. One controls the system's process of communicating the rotary encoder. This is a feature that was placed on the pad's controller to the heating pad. It is used to decode the user's desired temperature setting. From there, the Arduino sets the temperature to match the real temperature value of the heating element through PID control. The electrical components of the heating pad consisted of 5 subcircuits: the pulse width modulation circuit (PWM) that feeds to the heating element with ranging voltages depending on the user; the rotary encoder that communicates to desired temperature to the microcontroller (Arduino); the MAX6675 module that enables the microcontroller to communicate with the thermocouple – feedback of the system; and finally the wireless component with the NF2024 module and receiver module that will transmit and decode the desired temperature from the microcontroller to the heating pad.

The thermal conductivity, thickness, and quality of materials are all factors that affect the rate of heat through the system. In the future, we want to push for sustainability and utilize as much power being supplied to the system, all while keeping the product safe to use. We would like to be able to better model the system by showing how much power will be needed to maintain the heating pad exposed to skin at any adjustable temperature.

Constant improvement will be the key to this wireless heating pad's success. In the future, the plan is to add the feature of wireless charging, while also improving the control systems and coding with adjustable temperature settings. Using printed circuit boards (PCB's) to decrease the number of components is another important design element. Finally, a deeper heat transfer analysis using COMSOL will be done on the heating pad, in order to explore potential innovative ideas to enhance social, economical and environmental impacts.

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