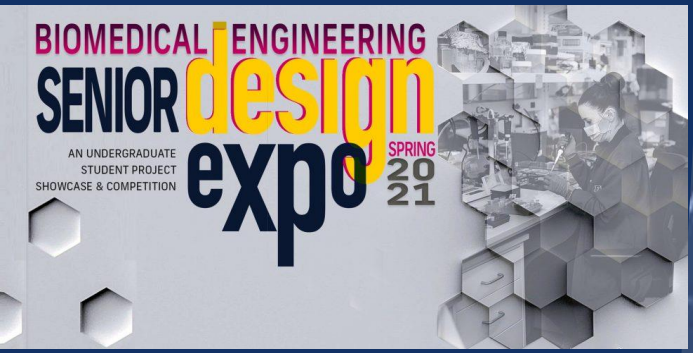
FIU | Engineering & Computing

Biomedical Engineering



DISCOVER / DESIGN / DEVELOP / DELIVER

Presented through the generous support of the Wallace H. Coulter Foundation.

MESSAGE FROM THE CHAIR

Congratulations Seniors!

As senior Biomedical Engineering students at Florida International University, you have come to the end of an incredible journey. Your Senior Design Projects are a reflection of your efforts and your capstone undergraduate experience.

Your work is an illustration of the many skills you have sharpened during the course of this yearlong project. you have discovered new ways of thinking, designed and developed an engineering solution for a practical problem, and collaborated with your teammates to deliver innovative solutions. It is encouraging to see your accomplishments and to have witnessed your growth as students.

As you embark on the next stage of your education and careers, keep the confidence that comes from having enhanced your knowledge, remain inquisitive and have the courage to achieve your dreams.

Dr. Ranu Jung
Wallace H. Coulter Eminent Scholar Chair in Biomedical Engineering
Professor and Chair of Biomedical Engineering

SENIOR DESIGN PROJECTS

Thursday April 15th, 2021

Post Stroke Hand CPM Rehabilitation Device: *RehabiliHand*

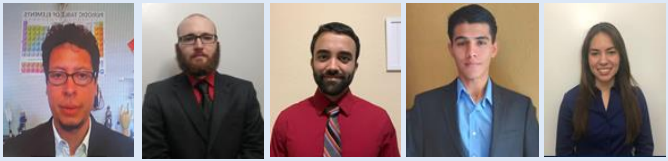
Team 1

Faculty Advisor: Zachary Danziger

Company Sponsor: Bio Engineering Labs Corp

After a brain stroke, survivors may suffer from disabilities that include permanent hand paralysis to some degree; however, by providing appropriate physical therapy, functionality of the hand could be substantially recovered. Current modalities fail to provide a cost effective, easy to use device that patients can operate at home as a complement to therapy in a clinical setting or as a substitute if such therapy is not possible. The objective of this project was to design, manufacture & assemble a medical device capable to safely deliver physical therapy to patients with hand paralysis while having the aforementioned characteristics. RehabiliHand is a hand Continuous Passive Motion(CPM) prototype that extends and flexes the finger joints of the hand with the ultimate goal of helping stroke survivors regain hand motor skills. This working prototype is a cost-effective, portable CPM modality with adjustability to different hand sizes, forearm lengths & speed. The prototype uses a novel interface that minimizes stress on the joints. In addition, it incorporates a novel holding mode to help patients putting the device on, facilitating ease of use in the home setting. This device has the potential to be used as physical therapy tool for different conditions resulting in hand impairments.

Team 1 *Duvian Rojas, Omar Morales, Adrian Alvarez, Alejandro Guilarte, Raquel Veiga Martin*



Bio Engineering Labs, Corp.
NEO TECHNOLOGY

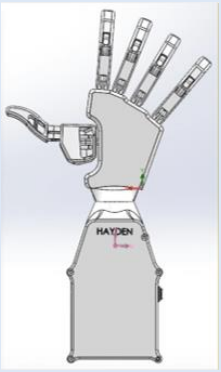
The Hayden 2: 3D Printed Pediatric Prosthetic Hand

Team 2

Faculty Advisor: Markondeya (Raj) Pulugurtha

Company Sponsor: Nicole Wertheim College of Nursing & Health Sciences, FIU

The Nicole Wertheim College of Nursing & Health Sciences (NWCNHS) has created a 3-D printed arm in conjunction with FIU Biomedical Engineering department for pediatric patients with missing upper-limbs (The Hayden 1). However, the dimensions as well as the design were not 'streamlined' enough for patients, making it difficult to handle. While The Hayden 1 demonstrated that the concept of a 3-D printed hand for children is possible, the prototype encountered difficulties relating to the functionality: 1) weight distribution uneven for user, 2) exposure of electronics safety hazard 3) unable to lift objects of more than 1lb. An updated prototype of the 3-D printed hand for pediatric patients was designed and manufactured, with new requirements, specifically a focus on a slimmer lighter design, water resistance, and ease of use, while keeping costs similarly low. The 3-D printing process was assessed for user friendly printing (MakerBot Replicator+); however, the final improved model was printed using Multi Jet Fusion technology in collaboration with Hewlett Packard (HP). Multiple manufacturing processes were explored in order to optimize the Hayden 2. The product resulted in an 84% reduction of cost and a known increase of 1.75kg in lifting capacity when compared to Hayden 1. The Hayden 2 final prototype will allow NWCNHS to launch a program with the goal of distributing prosthetic hands to children, with no cost to the patient's family and low cost to the organization.



Team 2 *Daniela Leizaola, Paula Orenes Sanchez, Thomas Schiffer*

FIU
Nicole Wertheim College of Nursing & Health Sciences

Finger+ : Modular 3D-Printed Partial Hand Prosthetic

Team 3
Faculty Advisor: Ranu Jung
Company Sponsor: Hanger Clinic

In the United States, an estimated 18,000 partial hand amputations occur annually. In order for an individual with an amputation to use their hand for functional tasks with the use of a prosthesis, the prosthetic must be first designed, fabricated, and fitted. This can take up to six weeks and on average about 3-4 visits with a prosthetist before a patient receives their prosthetic. Meaning that the individual may not be able to work or properly accomplish daily tasks for an additional six weeks. While some companies offer more expedited fittings, these are usually offered at a premium cost. This can inhibit insurance coverage and even prevent economically challenged populations access to an effective prosthetic. Pre-existing designs for prosthetic finger systems are not cost effective, with prices ranging from $3,500-$5,500 for a single digit. As a result, it is clear that delivering affordable partial hand prostheses in a timely and affordable fashion is highly desirable. Our aim is to produce a universal partial hand prosthetic device, featuring modular digits and an interface that functions for varying phalangeal (finger bones) amputations and hand dimensions with a production cost of approximately $120 or lower.

Team 3 *Allison N. Martinez Mejia, Condell Eastmond, Edward Sosa Jr., Gabriel A. Peña*

Improvement of Test Fixture for Stent Graft Deployment

Team 4

Faculty Advisor: Sharan Ramaswamy

Aortic aneurysms are a major cause of death every year. Endovascular repair is a technique where a stent graft is positioned in the aorta to treat aortic aneurysms. This procedure's success depends on preoperative preparation and a stent graft that can adequately fit the patient. Preoperative bench top testing on patient-specific models, leads to better clinical outcomes. Our sponsor specializes in creating patient-specific stent grafts for any given region of the aorta. However, the current test fixture lacks durability, is prone to cracking, and has a time-consuming connection mechanism. We sought to identify a tougher material that can withstand more testing cycles while being both durable and transparent. Our team also designed a new quick connection mechanism between the aortic model and a pulsatile pump that is leakproof and withstands aortic pressures. After performing tensile and fatigue tests on multiple materials, we identified the ideal material as Stratasys Aguilus 95A polyjet material to 3D print an aortic model. A safety clamp with a lever was also designed to be compatible with the 3D printed model by creating angled flanges. This newly improved test fixture will be a more effective method for testing stent grafts by our sponsor's engineers.

Team 4 *Nelson Abarca, Santiago Fossi, Kristy Menendez, Gabriela Rasch, Ana Valentin*

Physiological Device for the Detection of Venous Thrombosis

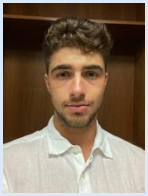
Team 5

Faculty Advisor: Michael Christie

Company Sponsor: Bio Engineering Labs Corp. - Duvian Rojas

Deep Vein Thrombosis (DVT) is a condition in which blood clots form in the lower extremities due to a lack of motion, insufficiencies in circulation, and other health factors. Approximately 60,000 to 100,000 deaths in the U.S occur annually due to venous thromboembolic events. Currently, DVT cases are expected to be on a rise due to COVID-19 and the increasing obesity epidemic of the American population. Current modalities for DVT detection are dependent on physicians identifying related symptoms which typically occur in later stages of DVT resulting in more intensive treatments or more invasive methods. Since the severity of DVT greatly increase as time passes without treatment, a system for high risk individuals to monitor themselves for possible signs of the early stages of DVT formation has been proposed and developed. The Physiological Device for the Detection of Venous Thrombosis (PD-DVT) was developed by Team 5 and offers a Thermal-Infrared Imaging technology which can monitor and warn individuals if the extreme skin temperatures associated with DVT are detected by the included integrated software analysis. PD-DVT is a low cost, ambulatory, non-invasive, and rapid scanning device that can be used every-day for the preventive care against DVT.

Team 5 *Brianna Valdes, Claudia Ponce Aportela, Henry Figueredo, Gabriel Menendez*



Bio Engineering Labs Corp

Dermal Resurfacing Attachment for Monitoring Speed (DReAMS)

Team 6
Faculty Advisor: Nikolaos Tsoukias
Company Sponsor: Apyx Medical

Skin resurfacing refers to a non-invasive cosmetic procedure for tightening the skin and reducing the visibility of wrinkles. The Renuvion system accomplishes skin resurfacing by applying helium plasma to the dermis, which causes collagen fibers to contract. Importantly, the energy density applied to the tissue depends on the speed at which the Renuvion handpiece moves across the skin. During the procedure, the user determines the handpiece speed by visually inspecting optimal and adverse tissue discolorations. Thus, surgeons seek an alternative, quantifiable method for monitoring the tissue effects. The proposed solution is the Dermal Resurfacing Attachment for Monitoring Speed (DReAMS) which tracks the movements of the handpiece and alerts the surgeon when they are outside the recommended speed range through visual and auditory outputs. The DReAMS design can measure speeds within an average percent error of 7% and detects changes in position of less than 3 mm according to verification tests. It also maintains a secure fixation when acted on by 2 + 0.5 lbs, has an average sample rate greater than 106 Hz, and can withstand temperatures of 100°C. Ultimately, the DReAMS can aid in reducing the risk of adverse effects while enhancing the Renuvion's effectiveness and ease of use.

Team 6 *Heriberto Nieves, Irene Cabanas, Claudia Iannini, Alexander Ruiz*




Emergency Cervical Collar with XPF Auxetic Foam

Team 7

Faculty Advisor: Joshua Hutcheson

Company Sponsor: Auxadyne

Emergency cervical collars assist with the stabilization of a patient's head and neck after serious injury. Studies have shown current modalities of emergency c-collars do not adequately restrict head and neck motion due to limited sizing availability. In a collaborative effort with Auxadyne, the innovative Auxetic Polyurethane Foam (XPF) was used to develop an adjustable c-collar that has the potential to combat prominent issues facing those in use. XPF foam differs from conventional foam as it displays negative-Poisson's ratio when stresses are applied while also remaining synclastic. Meaning, this foam can be stretched upon application to fit a greater demographic with varying circumferences. The foam has the ability to absorb a majority of applied forces and evenly distributing them throughout the system, mitigating stresses on a patient. Through multiple verification tests, it was determined that the cervical range of motion was limited to less than 10 degrees in each direction. The foam was able to absorb a force of 10 N, relieving the locking mechanisms of an added stress to maintain the desired position without rupture. This prototype was developed through applications of SolidWorks CAD modeling, 3D printing, and manufacturing techniques. The proposed design can be used in the future to spearhead advancements in the industry of emergency medical intervention. By better adjusting to patients unique anatomies, the system provides a decrease in cervical range of motion preventing further injury to patients during transfer within a pre-hospital setting.

Team 7 *Quianna Vaughan, Bridgette Meyer, Natalie Reyes, Adriana Aguilar, Antonio Fumero*

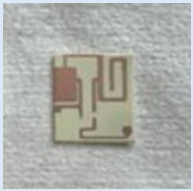
Near-Zero Power Implantable EEG Monitoring Device

Team 8

Faculty Advisor: Markondeya (Raj) Pulugurtha

Company Sponsor: Jabil Inc.

Of the 65 million people diagnosed with epilepsy worldwide, one-third will eventually develop refractory (drug-resistant) epilepsy. Popularly used epilepsy monitoring devices are not wireless and require the patient to remain in a clinical setting, where they are shielded from many potential seizure triggers. The implantation of our Near-Zero (RF) Power Implantable EEG Monitoring Device will offer patients continuous monitoring via a simplified backscattering RF topology that doesn't require DC power, potentially resulting in faster, accurate diagnosis with sensitivity approaching 15-20 microvolts. Other features of the device include biocompatibility, ease of manufacturability, and wireless recording under various physiological constraints, due to its compact dimensions. We present a prototype that was fabricated with a low-cost negative photolithography technique developed by the team. The device consists of a layered design containing an RF antenna and graphene-PEDOT:PSS coated electrodes. Verification protocols were designed to ensure a high SNR and RF communication. The results of these assessments indicate that our device facilitates the detection of simulated neural activity via the electrodes, as well as accurate relaying of that signal by the antenna. In the future, applications of this implantable device will allow for clinical use of long-term neural activity monitoring beyond the hospital setting.



Team 8 *Gabriela Alvarado, Shaylyn Grier (Team Leader), Jose Montes, Maria del Rocio Rodriguez, Angel Vega*

JABIL

Dental Composite Warmer/ Dispenser and Base

Team 9

Faculty Advisor: Wei - Chiang Lin

Company Sponsor: Werner Blumenthal Engineering

Dental composites are frequently used in dental clinics to fill in cavities and other holes in the teeth. Dentists frequently have issues working with the ceramics and composite resins employed during these procedures. One predominant concern is that if the filling is not properly heated to its optimal temperature and immediately applied on the tooth, it could lead to microleakage from the cavity due to the extended exposure time and/or eventual cracking of the composite.Currently, there is no solution to address this issue. The best chances a dentist has to reduce the risk for microleakage is to assure the composite is properly warmed so it is malleable enough and is not cured, making the application and smoothing as closely tight to the tooth's enamel as possible. With more than 175 million dental fillings that are performed every year, it is imperative to develop a device that heats up the ceramics and composites to their corresponding malleable temperatures in a more streamlined and efficient manner. Our team designed, developed, and tested a dental composite heat warmer composed of a heating base and mobile dispenser, that prepares the composites for the dentist to be ready for fillings.

Team 9 *Amanda Barreto, Mario Huayamave, Antonio Rosales, Michael Navarro*




Lower Limb Prosthetic Weight Adjustment Accessory

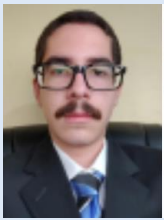
Team 10

Faculty Advisor: James Schummers

Company Sponsor: Nicole Wertheim College of Nursing & Health Sciences, FIU

The Lower Limb Prosthetic Weight Adjustment Accessory is a device that will be placed on a transtibial amputee's prosthetic socket in order to add weight. The weight can be added in one ounce increments up to 2 pounds and the device fits most adult socket sizes. This device will allow prosthetists and therapists to be able to adjust the weight of a lower limb amputee's prosthetic socket without the need of having to replace the entire prosthesis. This will fill a clinical need of quick, easy, and affordable adjustment of precise incremental weight for prosthetists to ensure that lower limb amputees feel more comfortable when walking in case the weight of their prosthesis is not correct. This will also change the weight distribution of the prosthesis which can possibly improve the irregular gait symmetry of lower limb amputees with improperly weighted lower limb prostheses.

Team 10 *Jonathan Cobos-Solis, Gianfranco Malanga, Jazzmin Harris, Carlos Otero*

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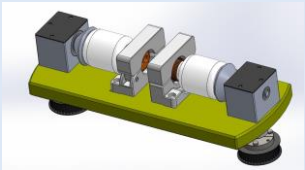
Islet Cell Concentrator

Team 11

Faculty Advisor: James Schummers

Company Sponsor: BIOREP TECHNOLOGIES, INC.

Type 1 diabetes (T1D) is an autoimmune disease that causes the destruction of insulin-producing pancreatic Islet cells. Increasing prevalence of T1D indicates the need to develop an affordable and lasting treatment. Islet cell transplantation allows T1D patients to gain insulin-independency. Currently, the process of isolating Islet cells requires two sequential centrifugation steps, risking the viability of the islet cells. To overcome this, Biorep Technologies proposed a centrifuge that continuously injects/extracts fluid. However, the centrifuge is time-consuming to operate and is unable to run at the desired Revolutions Per Minute (RPMs) leading to a low islet cell yield. We designed, prototyped and tested a new bottle holding mechanism that dramatically improved operation time. A root cause analysis was performed to identify elements that limited the attainable RPMs of the existing design. Based on this, we designed a dual-centrifugation system that successfully reached the desired RPMs for optimal isolation of islet cells in Solidworks simulations. These advancements will provide a new method of treatment for T1D patients.



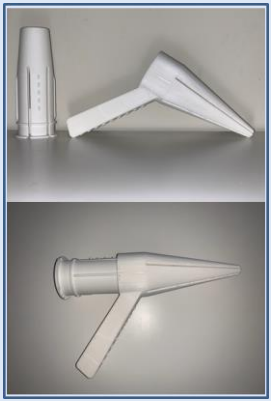
Team 11 *Melissa Fernandez, Kevin Pol, Christopher Tejada, Nasika Meadas*

BIOREP® TECHNOLOGIES

Bouquet Speculum

Team 12
Faculty Advisor: Jessica Ramella-Roman
Company Sponsor: Jean Bouquet

Cervical cancer is a fatal type of cancer that results from lingering human papillomavirus (HPV) in the cervix. The American Cancer Society estimated that in 2020, 13,800 new cases of cervical cancer would be diagnosed in the US (4,290 fatalities). Cervical cancer screenings rely on a speculum to access the cervix and obtain tissue samples. The traditional speculum consists of two blades that separate the vaginal walls for visibility. Using this speculum can result in an obstructed cervix view due to vaginal wall collapse in about 30% of females (from weakened muscles from childbirth, aging, excess weight, etc.), leading to inaccurate examinations, and higher rates of otherwise preventable cervical cancer. The project scope is to create a novel speculum for a more efficient detection and treatment of cervical cancer, while also preventing vaginal wall collapse. The disposable Low Density Polyethylene design features a handle with five petals and a dilator that induces a radial vaginal opening, allowing for an improved pressure distribution, and decreased stress concentrations. Our testing showed that our design offers higher cervix visualization, and capabilities to both withstand extreme vaginal wall pressures (without compromising visualization) and to be incorporated into the workflow (employing common gynecological tools).



Team 12 *Carlos Armas, Rayyan Naji, Valentina Roldan, Shadi Selkhi*

Dr. Jean Bouquet

THANK YOU
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Jabil Inc.

Werner Blumenthal Engineering

Nicole Wertheim College of Nursing & Health Sciences, FIU

Biorep Technologies, Inc.

Dr. Jean Bouquet

Dr. Sheila Clemens

ABOUT OUR PROGRAM

The Department of Biomedical Engineering at Florida International University (FIU) located in Miami is committed to preparing ambitious students who want to combine their love of problem-solving with their desire to help others, through this fascinating growing field that applies cutting-edge technologies and modern engineering techniques to improve healthcare.

Our Biomedical Engineer department is ranked #1 for bachelor's degrees awarded to Hispanics and #6 for bachelor's degrees awarded to African Americans. Nationally, we are among the Top 20 to offer BS degrees, Top 65 for research expenditures, and considered in the Top 30 of the most popular in the country. Florida International University is designated a Carnegie Highest Research (R1) and Carnegie Community Engaged Institution.*

**ASEE 2019, NSF HERD 2018, and College Factual 2020*

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Biomedical Engineering

DREAM, DISCOVER, INSPIRE, INNOVATE

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Department of Biomedical Engineering (BME)

Florida International University

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