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MCGILL DESIGN DAY 2021

Faculty of Engineering Capstone Project Exhibition

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Project Abstracts by Department

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Architecture

| ARCH-01: Flying In: A Modern Experience in a Closed-Loop System

In an isolated environment like Kuujjuaq, with limited available resources, a harsh climate, and countless off-road regions, difficulties such as visiting the site, transporting material or even monitoring the construction are very much present. To overcome this challenge, we propose the design of a self-sufficient pod while setting in motion new technologies. Using unmanned aerial vehicles (UAV swarms) as means of communication, transportation, construction, and operation, allows to coordinate processes and monitor tasks efficiently and beyond the line of sight. A material catalogue combined with drone technology facilitates the disassembly and site relocation process. Within the pod itself, technologies such as hydraulic systems and automated expandable spaces are incorporated to accommodate the needs of new and exiting individuals, whether it is to create larger living areas or reconfigure spaces that would diversify the experience in the pod. The users play a crucial role in the road towards attaining self-sufficiency, with multiple loops such as an aquaponics system, a rainwater and greywater disinfection process, and a closed loop human waste compost system. These lifecycles are made possible by leveraging the existing natural resources within the geo-biosphere, studying all living organisms present in the system and monitoring behaviours in order to benefit all beings. The pod calls for a welcoming and transforming experience for a 14-day quarantine period and highlights its potential for disassembly and re-use.

| ARCH-02: 3D Printing: The Solution in Times of Crisis?

The COVID-19 pandemic has underscored the need for everyone to have a safe home to shelter. Yet, more than 1.8 billion people – 20% of the world's population – lack adequate housing and access to essential services such as water, sanitation and electricity (Un Habitat, 2020). As the climate change crisis worsen and natural disasters become more frequent, this number will expand. The large-scale 3D printing technology could help tackle this issue by savings on labour costs, materials, and construction time. In Austin, TX, the 3D-printing company ICON has built code compliant tiny homes in 24 hours for $10,000. The first code-approved 3D printed house – by SQ4D – is currently for sale in Long Island, NY. Whereas most existing printed houses are made of a concrete mixture extrusion, I will explore the use of a biopolymer basalt composite developed by AI SpaceFactory (New York, NY) and validated by NASA. In addition to being 100% recyclable and biodegradable, this finer mixture would allow to print the outer shell into parts that can be assembled and disassembled. Only one prototype has been built with this biopolymer mixture. Uncertainties with respect to the insulation properties and the structural stability of the outer shell are remaining. Also, the current availability of materials – continuous basalt fibers and polylactic acid – could make the biopolymer less sustainable than recycled concrete.

| ARCH-03: Kargi Pods: Reducing Plastic Bottles Waste Through an Innovative and Effective Building Envelope

Kargi Pods aim to address the need for quarantine and social distancing with the current COVID-19 pandemic. The pod was designed to be on the hills of Kujjuaaq, Quebec, and it addresses the necessity of rethinking plastic bottle recycling and waste. More than 100 million plastic bottles are used worldwide every day,

but only a small portion of it is recycled; most of them end up in the Ocean and damage marine life. The pod rethinks how to use recycled PET bottles in a building envelope. The outcome is a Plastic Foam board that has superior mechanical qualities, incredible strength, waterproofing, and acts as a great insulator for the extreme climate of Kujjuaaq. The design of the pods is adapted to the sun path, the mountainous topography, the climate, and local architecture needs. At a distance, the pods look just like the characteristic rocks of the region of Nunavik and merge with the natural landscape. The quarantine facility is composed of 1- and 2- persons sleeping pods, and 2 separate common areas that enhance the sense of community. The pods can be configured in different ways depending on the use – for the quarantine-use, the different structures are spread out through the site to promote mobility and encourage a routine.

| ARCH-04: MyPod: Adapting to Situational and Individual Needs Through Circular Design

In these unprecedented times, pandemic-imposed social isolation has led to a rise in mental health issues and global consumption is quickly depleting the planet's resources. As universal needs shift, design methods must adapt. Offering personalized user preferences and learning from lived quarantine experiences, through an adaptive design, the pod and its surrounding community offers optimized and sustainable comfort. The system is composed of a circular design approach which applies urban mining to the city of Montreal, extending the life of the local recycled materials and eliminating additional waste streams. The digital twin tracing platform allows the project design team as well as tenants to access all information relevant to their associated pod and individualized profile. This digital pair tracks and updates the pod's building passport in collaboration with the design team and recycled material source, to predict the material and structural lifespan and prepare for necessary component repair or replacement. This technical approach provides the tools for a seamless circular flow, where user profiles inform opportunities for pod matching, reconfiguring, or recycling. This system can be globally applicable and cater to a range of climates, accommodating a diversity of users and adapting to prospective situational needs.

| ARCH-05: Carry on: A Biogenic Kit of Parts Designed for Disassembly

In 2010, the U.S Environmental Protection Agency determined that an estimated 104 million tons of materials were sent to landfills from project sites around the country, and 92% of that waste came from demolitions and renovations." To tackle this issue, we propose a prefabricated modular system to enable sustainable design and construction through the redefinition of a structure's lifecycle. Using the concept of Designing for Disassembly (DfD), a customizable Kit of Parts made of biogenic materials is developed to enable easy repairs and upgrades, adaptability in layout design, simplified joints that facilitate disassembly and more broadly an expanded life cycle. Studying various regions in Quebec allow us to develop a panelised system that caters to different social and climatic needs. Three covid-pods are proposed for Montreal, Kuujjuaq and Sept-Îles. Alternate end-of-life scenarios are developed for each region that extend the system's lifecycle. Our future design research would tackle ways to include bioclimatic strategies into the pod iterations to maximise its energy gain.

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Architecture

We believe this proposal can behave as a reference to help restructure our linear materials economy and generate architecture with an expanded and redefined lifecycle.

| ARCH-06: Growing Buildings: Prioritizing Renewable Materials and Energy in the Built Environment

In a construction industry heavily reliant on cement products, fossil fuel energies and other irreversible processes, professionals in the field will increasingly have to rise to the challenge of mitigating the impact of their work on unbalanced ecosystems. In order to alleviate GHG emissions, recent built projects (like Lemay and Provencher Roy's Arbora in Montreal) have prioritized the use of renewable materials and energy, leaving a smaller footprint on finite resources. Specifically, studies into mass timber and sustainably managed forests have demonstrated the material's potential for biogenic carbon storage and contribution of nutrients to its ecosystem in its end-of-life. By prioritizing materials like timber and hempwool and energy management strategies like solar energy and passive heat gain, designers can further minimize the embodied and operational carbon and energy demand of their work. We believe the integration of life cycle analyses at the design stage, in conjunction with proper documentation, can bring light to the carbon and energy impacts of design decisions and help designers make more conscious choices. If done properly, these decisions will not only have a tremendous impact on emissions and consumption but can increase biodiversity in our forests and contribute to the global carbon capture effort.

| ARCH-07: The Way of the Qamutik: Enriching Kuujjuaq Through Waste and Circular Design

Kuujjuaq is an isolated community that has a high demand for local material, since sourcing imports, in terms of food and building material, comes at a high cost. Using post-consumer materials for envelop and thermal battery design is economical, local, and efficient. Kuujjuaq has a potential local marketplace for biogenic insulation using wool from profitable Muskoxen farms and negatively contributes to GHG emissions. Kuujjuaq's climate features strong winds and permafrost that constantly change the landscape, snow is typically blown away with the wind, a raised floor and thin volume offer a path of least resistance to the wind and snow to prevent soil erosion. We propose that the resulting pod will exemplify that ability to use waste as a resource and support the cultural nodes of Kuujjuaq as well as vernacular modes of construction. Using local waste as well as local biogenic materials like muskox wool can support the livelihood of the community and support food security in the region.

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Bioengineering

| BIEN-01: Microfluidic-based Diagnosis of Methicillin- Resistant Staphylococcus Aureus (MRSA)

Methicillin-resistant Staphylococcus aureus (MRSA) is a contagious and multi-drug resistant bacterial infection which poses a multi-billion dollar challenge on North American hospitals. Current diagnostic strategies used in centralized laboratories take hours to days before a diagnosis is determined, and patients with invasive infections may die within a few days of culturing positive for MRSA. Rapid and sensitive diagnostic tools which can be integrated at the point of care can help hospital staff micromanage their patients and available isolation rooms, while patients will appreciate that their doctors can make timely and informed decisions on how to improve their prognosis. To advance towards this reality, we aim to develop a microfluidic platform that performs an expeditious, reliable, and automated diagnosis of the MRSA superbug at the patient's bedside. Our project focuses specifically on microfluidic channel design optimization as well as a heat & mass transfer simulation of the proposed microarchitecture to evaluate its feasibility as a medical device. This work will guide subsequent efforts to prototype the device in microfabrication facilities, to perform laboratory tests as evidence of its clinical value, and to confirm product-market fit through its adoption into the healthcare environment.

| BIEN-02: Planning of SARS-Cov-2 VSV vectored-vaccine candidate global production and distribution

The coronavirus (Covid-19) pandemic is undoubtedly one of the greatest health crises and challenges of our time. Vaccination is of utmost importance to prevent the spread of the disease. The aim of our project is to find ways to optimise the production of the SARS-CoV-2 VSV vectored vaccine candidate, as well as plan its distribution around the world using a distribution model. To plan the distribution of our vaccine, we are mainly focusing on three countries - Benin (low-income country), Brazil (middle income country) and Canada (high income country). In addition to this, we are also going to estimate the production cost of our vaccine and see how it compares to the current vaccines.
BIEN-03: Design Improvements on a Robotic Spine

A benchtop robotic spine is being designed and manufactured to act as a model for the movement of a real human spine under different loads. It currently consists of spinal bones, a rib cage and pelvic bones as well as select vertebral muscles; it lacks connective tissues and the majority of its supporting muscles. However, spinal stability relies significantly on the tensile effects of a multitude of non-Newtonian and non-Hookean connective tissues and muscles and as such, it cannot be effectively modeled as a column of bones with a classical Newtonian approach. The thoracolumbar fascia (TLF) is a complex network of connective tissue in the lower back and abdominal regions that is critical for spinal stability and distribution of forces on the spine. To compensate for the spine model's lack of connective tissues, fascial tissues, and muscles, a TLF analogue based on the engineering concept of tensegrity was designed and integrated to the model through a tunable extension spring system. Moreover, seventeen artificial intervertebral discs with reduced stiffness were added to increase the robotic spine model's physiological accuracy.

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Bioengineering

| BIEN-04: Quantifying Cellular Forces with Deep Learning

A physics-aware deep learning system was developed to infer cellular traction from only the morphology/shape of the cell which can be easily acquired by cell imaging. Cellular forces dictate cellular processes and the onset and progression of diseases such as cancer and asthma. However, the application of cell mechanics is hindered by the costly, time-consuming, and complex procedures to measure the forces. Besides, the current methods completely depend on in-vivo experiments, so cannot exceed the experimental parameter space. Sometimes, the accuracy is limited due to inverse problems. To resolves the limits of the current methods and to revolutionize the methodology in the field of cell mechanics, a comprehensive and generalizable physics-constrained deep learning system with adjustable physical and biological parameters is developed to accurately and instantaneously infer and simulate the dynamics in cells and tissues under different conditions from merely the time series of cell morphology. Moreover, the application of this project exceeds cellular dynamics, as the fundament of the project is modelling physical problems with deep learning.

| BIEN-06: Designing a Web Interface for Sequence Function Inference

Our design project consists of a web application that can deliver the power of machine learning genomics to biologists and students alike. While these algorithms exist in plenty, they often lack the accessibility to be useful to the professionals who need them most. The web application combines two algorithms: the first, RNAtracker, generates a prediction score corresponding to whether the input sequence is an RNA-binding site. The second algorithm, PhyloPGM, leverages evolutionary information from orthologous sequences to increase the accuracy of RNAtracker. The result is an application that delivers the results of a biological prediction in a user-friendly way with data-driven visualizations, as well as outputting the raw outcomes for functional purposes. The versatility of the application makes it useful to and usable by biologists, students, and layman alike.

| BIEN-07: Design of a degradation model for mechanical testing of equinearticular cartilage tissue for osteoarthritis testing applications

Osteoarthritis (OA) is a degeneration of diarthrodial joint and a major source of pain for the ageing population. By the year 2050, it is expected to affect 130million people worldwide according to WHO. As such, the demand for improved therapies addressing the structural deficiencies in OA joints is elevated. The project presented herein attempts to present a sterile procedure allowing for long-term characterization of cartilage and subchondral bone explant co-cultures as a model for osteoarthritis. Characterization of the explants is done by mechanical testing, live-dead cell assay and histology. Ultimately, this project allows for a better understanding of the impacts of osteoarthritis on the diarthrodial joints, allowing for more effective treatments and solutions to be implemented, potentially improving the lifestyle of those affected.

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| BIEN-08: Global Production and Distribution of SARS-CoV-2 RBD

Following the global spread of COVID-19, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), several ongoing clinical trials have emerged to develop vaccines and medicines for the prevention and treatment of the contagious disease. We propose a global production and distribution strategy for the SARS-CoV-2 vaccine, specifically, the RBD recombinant subunit adjuvanted vaccine candidate. Additionally, we are programming mathematical models such as the Susceptible - Infected - Recovered (SIR) model in order to capture how the variation in immune responses influences population-level infection dynamics with vaccination. The flexibility of our vaccine manufacturing platform extends the procedure towards future vaccine development against other diseases. Production upscaling is carried out by transferring samples to bigger bioreactors through a series of steps after the cells reach a certain density. We propose an alternative purification technique using “teabags” to accelerate the downstream processing. The global distribution strategies take into account the infrastructures and medical facilities available in high- (i.e. US, UK and Canada), middle- (i.e. China, India, Argentina) and low-income countries (i.e. Rwanda and Ghana).

| BIEN-09: Engineering a Biomedical Diagnostic Device for the Direct Detection of Pathogens

Lateral flow assay technology brought affordable, portable, user-friendly urinalysis to consumers in the form of take-home pregnancy tests. This concept can be applied to any analyte present in urine, provided the biorecognition elements of the biosensor have been tailored to it. Using this principle, LFAnt medical is developing disposable diagnostic technology for the detection of sexually transmitted infections. Our group investigated a method to improve the sensitivity of the product.

| BIEN-11: Improving the attachment mechanism of closed-suction surgical drains

Closed-suction surgical drains are used as a postoperative drainage system to prevent fluid accumulation in wound sites. Currently, sutures are used to hold them in place by knotting the sutures around the drain tube and then anchoring them in the skin. This allows slight drain tube sliding, increasing the risks of postoperative complications and creating a need for a more secure attachment mechanism. In this project, two alternative anchorage mechanisms were designed and tested, both of which consist of two-part anchorage to ensure stable drain tube attachment. Each mechanism secures the drain from both inside the wound as well as externally, preventing accidental drain tube displacement. These mechanisms are compatible with present surgical drains and simplify surgical drain installation while decreasing the risks of drain tube sliding and premature removal.

Bioengineering

| BIEN-12: Engineering an efficient yeast chassis for production of cannabinoids

With the expanded use and increasingly permissive legislation of cannabinoids, their applications and production have gained more interest due to their medicinally-attractive properties. However, their widespread use for research and therapeutics is limited by current conventional plant-extraction and chemical synthesis methods due to low cost-effectiveness and complexity of purification. Heterologous production of cannabinoids in engineered yeast chassis has the potential to address these limitations, but further engineering is required to obtain higher cannabinoid yields. In this project, bottlenecks in the synthetic production pathway have been identified and theoretical design aims have been proposed to increase availability and conversion efficiency of three important precursors: hexanoyl-CoA, malonyl-CoA and geranyl diphosphate to synthesize cannabinoid products. Experimental setups were initiated for the expression of a C6-fatty acid acyl-ACP thioesterase gene candidate to obtain an intracellular cytosolic source of hexanoic acid and of a malonyl-CoA genetic sensor in yeast. Further development on both approaches will increase the availability of hexanoic acid and malonyl-CoA for the synthetic production of cannabinoids in yeast.

Chemical Engineering

| CHEE-01: Biotransformation of Ferulic Acid into Vanillin via Amycolatopsis: A Nature-Inspired Substitute for Vanilla Pods

Vanillin is one of the most in-demand aroma ingredients in the food, pharmaceutical and cosmetic industries. The scarcity of natural vanilla pods has encouraged the development of chemical synthesis pathways to respond to the high market demand at lower prices than natural vanilla, using ferulic acid as a precursor which can be sourced from lignin. In the recent years, biotechnological processes have emerged to promote sustainable and cheaper production, where Amycolatopsis bacteria are praised for their high tolerance to vanillin toxicity levels and their consequent high yield. Our team proposes a 2-step fed-batch process involving a dual-reactor system, optimized for a production basis expected to meet 5 % of the total Canadian production of Vanillin.

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Electrical and Computer Engineering

| ECSE-DP01: Designing an app to match and track patients and volunteer hospital navigators at St. Mary's Hospital in Montreal

It has been shown that volunteer visitors play a great role in improving patient care, and by having a streamlined process to refer patients, assign volunteers and perform continuous feedback on these interactions, this process will not only be more efficient for volunteers, but also allow the volunteer coordinators more time for initiatives to improve this service. The goal of this project is thus to optimize the volunteer navigation program overseen by the St. Mary's Hospital and McGill Department of Faculty Medicine by creating a set of applications to digitize the program and to address the efforts in reducing the administration complexity in healthcare.

| ECSE-DP02: Video Text Retrieval System

Online videos have made their way to people's sight as an imperative part of the lifestyle. Platforms like Youtube support powerful searching functions that relate videos to descriptions. However, the search only targets the video as a whole, rather than locating a specific action in the video. To achieve this goal, the team will start with an existing computer vision work that matches texts to videos. Then the team implemented the contrastive loss function on the model to compare the results. Eventually, the team is going to examine the new dual encoder model on a hockey dataset with noisy labels.

| ECSE-DP03: Static and Dynamic Malware Analysis and Classification

The field of cybersecurity will become even more critical as we rely and depend more and more on computers. In recent years, major corporations and governments have fallen victim to cyberattacks, and this trend is not going away. One common way to execute such an attack is using malware. By running and analyzing the malware in a safe, isolated environment, its features can be extracted. These features serve as inputs to our ML model for our end goal to develop a malware classifier.

| ECSE-DP04: One-Stop Shop Application for Caregivers

Behind every disabled or ill patient, there is likely a caregiver whose essential role is often overlooked. They are the patient's eyes, ears and helper when it matters the most. It is thus important to give them the necessary resources to ensure that they remain in an optimal physical and mental state to deliver the best services. This project aims to develop a mobile application that will primarily evaluate caregivers' health condition through questionnaires by generating personalized reports and provide appropriate resources and education material to stay healthy.

| ECSE-DP05: Cell Forces Data Analysis Suite

Researchers at the Bio Active Materials lab typically perform complex analysis of cellular images in order to gain insight on a given cell's mechanical properties.

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Today, these analyses are performed by running a MATLAB project that creates significant friction for researchers due to a combination of code complexity, manual operation, and lack of source control. Our capstone focuses on reducing this friction when performing a common analysis technique, traction force microscopy (TFM), by introducing a new software suite that enables researchers to gain greater insight on their results through efficient manipulation of the data, all within a web browser.

| ECSE-DP06: Design and Construction of an MRI Compatible Foot Heating Device

Putting an arterial line in the process of sampling arterial blood during MRI scans is a more difficult process compared to venous blood sampling. An alternative is to warm up venous blood above body temperature and then collect this “arterialized” venous blood. The goal of this project is to design an MRI-compatible foot heating device, where temperature threshold is adjusted under a control system implemented using Arduino.

|ECSE-DP07: Machine Learning Deployment Pipeline Optimization

The project is to implement an optimized pipeline that can accommodate machine learning models with different Python versions and framework types to mia platform. Mia helps its users to build and share machine learning apps; its goal “making AI accessible to everyone” motivates this project. Two deliverables will be carried out in this project. First, a deployment pipeline is developed such that different virtual environments can be provisioned algorithmically depending on each app’s needs. Second, the pipeline is optimized such that it can automatically scale up/down depending on the number of requests sent by users at any given time.

| ECSE-DP08: Deep Clustering

| ECSE-DP09: STM32 IoT Smart Alert System

Today, with the development of IoT, we live in a world that is connected more closely than ever before. This is thanks to the development of sensors and telecommunication technologies. In our design project, we leverage the hardware potential of the STM32 IoT Development board, combining it with AWS IoT infrastructure to create a smart alert system that will monitor the outside environment and notify the user through the cloud.

| ECSE-DP10: Graphical User Interface for Film Analysis Software

| ECSE-DP11: Educational Mobile App for Type 1 Diabetes Patient

Type 1 diabetes (T1D) is a chronic medical condition requiring intensive insulin therapy for life, where self-management is essential for adequate glucose control to prevent complications. Transition from pediatric to adult diabetes is

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fragile because many patients are not able to keep up with self-management skills. This project aims to create a smartphone application that would be used as an educational and management tool, geared specifically for patients transitioning from pediatric to adult care and those who need further tools to optimize treatment.

| ECSE-DP12: Virtual Circuits Lab

Studying and working from home have become an inevitable trend since the coronavirus disease 2019 (COVID-19) pandemic. To ensure teaching quality and smooth progress of academic research, we decided to implement a web-based virtual circuits lab which allows both students and professors to design and perform electrical experiments remotely, and at the same reduces the hazards involved in electrical experiments as well as eliminates the cost of purchasing physical circuit components. The goal of this project is to create a web application for students taking elementary circuits courses and provide the possibility of future program expansion.

| ECSE-DP13: Centralized Intelligent Coordination of Multiple Robots

The goal of this project was to create a proof of concept for centralized, intelligent coordination of multiple robots. More precisely, to create a system that can wirelessly receive data from a team of robots, make intelligent decisions based on that data, and then transmit instructions to each robot to serve its decisions. To accomplish this, we have designed three robots that communicate with a server via Bluetooth, and the server is running a reinforcement learning agent that guides the robots. Additionally, a simulation of the system has been built on which to train the reinforcement learning agent.

| ECSE-DP14: An RNA Bioinformatics Platform to Accelerate Biomedical Research

The goal of the project is to develop a platform that will unify multiple algorithms implemented by the Waldispühl research group to aid in RNA research. Currently, in bioinformatics, most of the tools used for RNA modeling and sequencing are functional, but not user-friendly. This lack of accessibility impedes RNA bioinformatics researchers from being able to fully leverage the tools that have been designed to handle the massive computations required in the field. Furthermore, all the developed tools operate independently of each other. This platform aims to eliminate the need for users to manually re-enter data, and to allow for an optimized workflow between tools.

| ECSE-DP15: Haven-AI Benchmark

Haven-AI framework is developed to help people boost their productivity by minimizing their efforts of modifying systems for large-scale end-to-end machine learning experiments. Through creating benchmarks and taking part in machine learning competitions building atop of Haven-AI, the team implemented state-of-the-art optimizers, models, loss functions, and other techniques for optimizing

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the experiment results. In addition, the team also integrated job schedulers into the framework to allow the future users to train their model from different platforms. Additionally, a website was also implemented acting as a showcase of the projects and the functionalities of the framework.

| ECSE-DP16: Machine Learning Techniques Circuit Modelling

| ECSE-DP17: Identifying Penalties in Hockey Videos

Identifying penalties in short hockey videos is a challenging task in computer vision due to the fast and complex movements of the multiple actors involved. While recent research has been done in the field of action recognition, creating a model that is both robust to the variance of real-world scenarios as well as responsive to intricate actions continues to be a problem faced across many domains. With this project, we aim to create a system that can classify the most common penalties within short clips from broadcasted hockey game videos.

| ECSE-DP18: Microcontrollers for Capturing Fencing Point System

In the current market, there exists no reliable and accessible wireless fencing scoring system. Fencers must go to specialized fencing clubs to practice the sport, which includes a substantial upfront fee and no method of tracking fencers' improvement. Our product allows fencers to fence anywhere at any time and track their progress by recording when they have been hit. Our product uses Bluetooth technology to communicate with fencers' mobile devices and allows for a multitude of features on a mobile application such as point keeping, progress tracking, and practice planning.

| ECSE-DP19: Imaging System for Navigation Assistance for the Visually Impaired

| ECSE-DP20: Building a Scalable Web App for Stocate

Stocate is a social enterprise which aims to support and promote local businesses. It aims to connect customers with local products for the benefit of the community and the environment. Its online platform leverages the power of online retail to better equip local business owners to navigate through the difficulties of the COVID-19 pandemic. The objective for our team is to migrate the website from SquareSpace into a React website. We also aim to implement additional features, such as user analytics to ultimately improve the user experience.

| ECSE-DP21: RNA Bioinformatics Platform to Accelerate Biomedical Research

The purpose of this project is to combine existing RNA research tools developed by the Waldispühl group at McGill University into a unified, user-friendly platform that can help transform biomedical research. This portion of the project covers the backend infrastructure of the platform. The project is built with the collaboration

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of another design team that is working on the front-end portion.

| ECSE-DP22: Frozen Pizza Production Line Controls Upgrade

| ECSE-DP23: IoT Infrastructure Architecture – With More Immersive Experience

As the IoT industry is growing, the quantity of IoT data grows abruptly in the near future, hence two questions rise: what data are useful and how the data need to be analyzed. In this project, we focus on finding the methods of extracting, analyzing and utilizing potentially useful data with the application of artificial intelligence and appropriate machine learning algorithms. We chose Google Cloud Platform as the development environment and successfully realized facial recognition on STM development boards.

| ECSE-DP24: Acoustic Monitoring of Neonatal Respiration: Signal Processing and Machine Learning

Infants in the neonatal intensive care unit suffer from frequent apneas - periods when breathing ceases - which may result from the lack of central drive or from obstruction of the airways. It is important to detect apneas and classify their origin to properly treat them. There is at present no reliable, efficient, clinically usable way of detecting and classifying apneas for neonatal patients. This project consists of doing continuous, real-time signal processing on chest audio obtained to accurately detect the presence of apnea and to classify the detected apnea as either central or obstructive in nature.

| ECSE-DP25: Touchless Retail Experiences

| ECSE-DP26: Prometheus Integrated AI Simulation

| ECSE-DP27: Summarize Me

| ECSE-DP28: MedicAll

| ECSE-DP29: League of Legends Supervised Learning - “DodgeBot”

In a League of Legends, sometimes it is beneficial to “dodge” (quit) a game before it begins and accept the small penalty instead of playing a game you know you will lose. The goal of this project is to use a supervised learning model to determine the outcome of a game based on the champions (characters) selected allowing players to decide if playing or dodging a game is the best plan of action. We retrieved and cleaned data from past games using Riot Games’ public API, implementing a machine learning mode and a User Interface.

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Electrical and Computer Engineering

| ECSE-DP30: A Facility to Link Researchers and Health Care Professionals

This project aims to strengthen the links between the Medicine faculty at McGill University with its clinical sites. It involves the building of a platform / database to link doctors, nurses, and other health care professionals in the 10 university primary care clinics with researchers in the Department of Family Medicine at McGill university. There are different types of user with different privileges. General users should be able to log into the system and either create a project or connect with other. Non-general users should be able to manage authentication and projects.

| ECSE-DP31: Deep Learning in Quantifying Cellular Forces

| ECSE-DP32: Stocate II

| ECSE-DP33: Haptic Dance Shoes

Have you been told that you have two left feet while dancing? Perhaps you have a hard time following the movements and timing of dance teachers. Our project aims to solve these problems by using haptic dance shoes. Through multiple actuators placed in the shoe, we can provide tactile cues that help new dancers understand the basics of dance, such as tempo and posture. Our software also has a visual component, where teachers and students will be able to observe the movements of the dancer's feet more closely.

| ECSE-DP34: Development of an Android App for a Local Startup (Fygo)

| ECSE-DP35: Machine Learning App Builder

| ECSE-DP36: Convolutional Neural Networks for Computer Vision Aided Quality Assurance in the Food Industry

Food health and safety have always been a major concern for producers and distributors. The industry has continuously adapted new technologies in order to increase efficiency and throughput while also emphasizing quality control. We are trying to identify and propose a method for the identification and classification of agricultural produce using images from multispectral sources. This project is separated into two main sections: Firstly, the choice of the convolutional neural network model, an investigation into its scalability and ability to increase the range of produce handle; secondly, we are investigating the grading of quality based on images from multispectral analysis.

| ECSE-DP38: MyMeter: Body Measurement Analysis for Online Shopping

Clothing sizes are often inconsistent between stores, which makes it difficult to

find the best fit. This is further exacerbated when shopping online, since clothes cannot be tried on. Additionally, size charts are hard to find or use if one is not accustomed to measuring themselves. MyMeter is a Chrome extension that recommends the best clothing size when shopping online. The user provides a set of pictures for the computer vision algorithm to estimate their body measurements. Then, when shopping online, the web scraper extracts the size chart and compares it to the measurements to determine the best fit.

| ECSE-DP40: McGill Python SPICE

The project is a SPICE (Simulation Program with Integrated Circuit Emphasis) library natively in Python which supports the functionalities of SPICE in language(s). The library allows SPICE netlists as input and simulates a circuit by performing core SPICE functions and circuit analyses. The library includes circuit element models for linear and non-linear elements. We developed a software framework that performs large scale mathematical computations, parses netlists and provides visual and tabular output(s) of the simulation. We adapted Agile SCRUM for software development and implemented automated testing for CD/CI. We mentored two design teams to continue development in upcoming semester(s).

| ECSE-DP41: Blockchain in Healthcare - Requirements and Specifications

Blockchain systems are widely used in the realm of cryptocurrencies. The words Bitcoin and Ethereum are all familiar to us. However, blockchain is now integrable in a variety of industries. Our design project aims to tackle the healthcare industry data management systems and better define requirements to scale blockchain. With the onset of the pandemic, it is imperative that patient data is unified in a single database that can be widely used by multiple medical and healthcare related institutions. With this innovation, we aim to streamline healthcare record management with complete privacy, security, transparency, immutability and reliability.

| ECSE-DP44: IoT Infrastructure Architecture with Amazon's Ecosystem

| ECSE-DP45: Connectivity Patterns Visualization in Brainstorm

Brainstorm is an open-source scientific application for multimodal brain imaging developed with MATLAB and Java. This project consists of augmenting a visualization tool within Brainstorm, which shows connectivity patterns computed from MEG signals that are transformed onto a brainspace and can correlate relevant regions of interest based on user-customizable atlases. Since this tool's current dependencies on OpenGL and Java may no longer be supported by MATLAB in the future, our project focuses on creating a new visualization tool that uses only MATLAB Graphics Objects and contains more user-interactive and user-friendly features.

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Electrical and Computer Engineering

| ECSE-DP46: Avionics System of High-Altitude Balloon

In addition to meteorological observations, high-altitude balloon (HAB) has become a platform to perform near-space experiments such as imagery capturing, satellite testing and other environmental experiments. This project is part of the early phase of McGill Space Group's blueprint of pivoting the research focus from high-cost satellites to a low-cost and flexible alternative, HAB. The goal was to prototype the avionics system of a HAB. The first part of the project focused on hardware design and selection, followed by software development as the second part. Unit tests of subsystems and integration tests were also conducted.

| ECSE-DP48: Sensors for the Acoustic Monitoring of Neonatal Respiration

With central apnea, abdominal and chest movement is present. However, abdomen movement is not present in obstructive apnea. Therefore, central apneas are easily detectable by current ECG technology, whereas obstructive apneas are not. The goal of incorporating acoustic monitoring is to use it as a measure of the respiratory flow, and compare it with accelerometer readings in the abdomen to classify obstructive apneas. This capstone's focus is to create a device that combines ECG, accelerometer, and acoustic monitoring that can be substituted in place of one or more of the leads used currently on NICU patients while maintaining biocompatibility.

| ECSE-DP50: Data Visualization and Social Distancing

| ECSE-DP55: A Facility to Link Researchers and Health Care Professionals

| ECSE-DP56: Greenification of a Remote Mine

The motivation of this project is to design an energy storage solution for the energy produced by the wind turbines at the Raglan mine in northern Quebec. Wind turbines have irregular energy generation which makes them an unreliable source of energy compared to diesel generators. Thus, by putting in place a 4MW electric boiler or a battery energy storage system, we will be able to protect the mine's diesel generators from breaking down when too much power is inputted. Our team will be presenting an implementation plan assessing the most advantageous solution based on environmental and monetary costs.

| ECSE-DP57: Modular Solar Station

| ECSE-DP58: Mixed-Reality Platform for Simulation and Synthesis of Multi-Modal Hallucinations with Applications to Schizophrenia Treatment

Schizophrenia is a serious mental health condition that can be characterized by hallucinations and psychotic episodes. Current treatments for this condition

include antipsychotic medication and electroconvulsive therapy, both of which can be ineffective. This project aims to deliver an alternative treatment using Avatar Therapy, the use of avatars in an AR/VR setting, which has been proven to be effective. Our main goal is to create the necessary building blocks to advance this project. We have been working on the main interfaces for the avatar building process and environment setup, and helped in developing vocal-based stress detection platforms.

| ECSE-DP60: QuadFalcon AYS

| ECSE-HT01: Analog RF Self-Interference Canceller for In-Band Full-Duplex MIMO Systems

In-band full-duplex radios can potentially double the data throughput compared to half-duplex systems, through transmitting and receiving simultaneously in the same frequency band. One of the largest problems to IBFD is the self-interference, which is the radio's transmitted signal reaching its own receiver, at a power level much higher compared to the desired signal from a remote radio. The SI heavily distorts the desired signal and must be eliminated through multiple SI cancellation stages for successful decoding of the desired signal. In this thesis, techniques for tuning the radio-frequency canceller and jointly tuning the RF and baseband cancellers are developed.

| ECSE-HT02: Dynamic Power Cap and Regenerative Braking Control in a Formula Style Electric Racing Car

| ECSE-HT03: Implementation of a Lock-In Amplifier for UV PCR Tests

| ECSE-HT05: Polynomial Chaos Techniques for Uncertainty Quantification

| ECSE-HT07: Multichannel Real-Time Plasmonic PCR with UV Detection

Over the past year, COVID-19 has spread exponentially around the world, initially overwhelming hospital staff due to the amount of active cases. Today, the most common method of diagnosing patients with COVID-19 is the real-time polymerase chain reaction (RT-PCR) which can be done under five minutes. Professor Andrew Kirk in the Photonics Group of McGill University led a group of post-graduate, graduate, and undergraduate students to work on making a plasmonic RT-PCR that utilizes gold nanorods for heating, and a UV detection system for concentration analysis to develop a kit that can present results in under a minute.

| ECSE-HT08: Multichannel Real-Time Plasmonic Polymerase Chain Reaction with UV Detection

The quantitative Polymerase Chain Reaction (qPCR) is considered the gold-

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standard SARS-CoV-2 diagnostic methodology. However, various limitations of traditional qPCR devices, such as long reaction time, high costs, and complex structure, obstruct their large-scale deployment for Point-of-Care (POC) diagnostics. To overcome these drawbacks, the Photonic Biosensing Laboratory has developed an ultrafast label-free qPCR platform, which conducts the DNA amplification and real-time monitoring using pure optical methods. This platform provides a cost-effective, time-efficient, and reliable qPCR diagnosis solution for POC testing. Aiming at future academic research, we further proposed a more efficient multiplexed qPCR system using coupled VCSEL arrays and UV LEDs.

| ECSE-HT11: ZeroWaste

PROJECT ABSTRACTS

Mechanical Engineering

| MECH-01: Oceanic Drifter Deployment/Acquisition

The project requires that a modular mechanism be designed that can deploy and reacquire drifters (floating sensor platforms) in an oceanic environment. The mechanism shall attach itself to an autonomous surface vehicle (robotic boat of a catamaran class) in a way that is ergonomic to attach/detach in the field.

| MECH-02: Small Scale Fluidised Bed for Powder Treatment and Powder Separation

The goal of the project is to develop a small-scale fluidised bed for powder treatment. The unit is to have two functions. The first function will be to treat the surface of the powder by injecting different gas (dry or humid nitrogen/argon). The second function will be to separate the powder particles as a function of size distribution. The two functions are to be ran separately. Constrains on the apparatus size, powder size to be compatible, etc, will be discussed. The demonstration will be done using plastic and ceramic particles.

| MECH-03: Suspension Design for Baja SAE

The McGill Baja is a single seat off road race car designed and built by undergraduate students. The overarching objective of this project is to design and manufacture a suspension assembly for the MB21 prototype. The overall design will be very different from previous year's designs. The team will be moving on from a two wheel drive vehicle to a four wheel drive vehicle.

| MECH-04: Drivetrain Design for Baja SAE

The McGill Baja is a single seat off road race car designed and built by undergraduate engineering students. The overarching objective of this project is to design and manufacture a drivetrain assembly for the MB21 prototype. The overall design will be very different from previous year's designs. The team will be moving on from a two wheel drive vehicle to a four wheel drive vehicle. The drivetrain team will have to work closely with all other systems on the car to accommodate every system's needs while accomplishing their own goals. The drivetrain team is responsible for the gearbox, final drive components, and drivetrain.

| MECH-05: Decoupled Roll & Heave Suspension Actuation System

McGill Formula Electric is redesigning our carbon fibre chassis and are in a unique position to implement an advanced suspension system which will allow more control over vehicle setup and performance. In an independent suspension system, the likes currently being used by MFE, each corner of the vehicle has a single spring which is actuated during heave, roll and pitch. The ability to tune the roll mode independently is of vital importance since our vehicle is considered to be high downforce and is, as a result, very sensitive to roll motion.

This project involves performing kinematic and vehicle dynamic analysis to

determine the ideal system configuration, and then designing the suspension components, including a damper cage to convert two of our existing compression dampers to handle both compression and tension, which is required for the roll dampers.

| MECH-06: Design of a Brake Dynamometer to Assist in Brake Rotor & Pad Material Selection

The goal of this project is to develop a Brake Dynamometer to analyze the thermal performance of any pad and rotor combination. The dynamometer will allow for a variety of brake rotors and pads to be tested interchangeably so that their performance can be assessed under different racing conditions. The braking stresses applied on the dynamometer will be similar to those experienced in a race scenario, allowing us to validate our material selection for our brakes and rotors. The design of the dynamometer will require Finite Element Analysis to ensure that it can withstand the test braking forces that will be applied. Furthermore, it must be compatible with the testing rig used by the team to test the vehicle's motors. The design will be designed for optimal usability, efficiency, and cost.

| MECH-07: Design of inverter cold plate for FSAE electric race car

McGill Formula Electric is a student run design team that designs and builds an open wheeled race car to take part in FSAE competitions. The team recently acquired in hub motors with quad inverters for the next iteration of the car. The inverters will need to be repackaged to improve weight distribution and overall component packaging of the car.

The objective of the project is to design a new cold plate to facilitate the repackaging of the inverters. The cold plate must be designed to minimize weight while also providing sufficient cooling for the inverters.

| MECH-08: Aerospace Composites Recycling Prototype

Carbon fibre prepregs are the most widely used raw material for making high-performance composite structures. They consist of dry fibre impregnated with a partially cured polymeric resin and they represent a very significant portion of the total manufacturing cost of a given structure. Current manufacturing practices, however, generate large quantities of prepreg waste, which poses both a financial burden on the manufacturer and a negative environmental impact. Several recycling solutions are being studied at the lab scale, but none have reached the level of maturity necessary for industrial implementation. This project aims at designing and building the first prototype of a commercially viable recycling machine that transforms prepreg waste collected directly from an aerospace manufacturer into a high-performance compression moulding compound.

| MECH-09: Autonomous Train Testbed

The focus of this project is building a small train testbed to test autonomous train

navigation and control methods. Students will spec a suitable train (i.e., track, locomotive, trollies) set-up, ideally a COTS setup. Students will spec sensors and requisite data collection hardware (i.e., micro computer or controller). Students will then specify how sensors and other hardware should be mounted. Should time allow, students will design and test their own navigation and control solutions.

| MECH 10: Shrink Wrapper Machine Improvement

The project is related to the food industry, namely, to the mass production of pizzas. The goal is to optimize pizza packaging. The pizza packaging is an automated process.

Two teams are required for this hybrid project. ECE students will improve the temperature control system on Allen Bradley PLC to prevent temperature overshooting or going below set point. MECH students will analyze the existing process and define the sources and the mechanism of pizza/film jamming.

| MECH-11: Freehand Orthopedic Targeting System

Targeting of Nail for the purpose of inter-locking with a pin or screw has for a long time been a problem for the orthopedic industry. Surgeons often rely on a freehand method where the position of the screw hole in a nail is identified intra-operatively via c-arming and the hole is prepared without the any guidance (hence the terminology freehand). The objective of this project is to develop a radiolucent targeting sleeve that will assist surgeons when performing freehand targeting.

| MECH-12: Special Seating Project for People with Disabilities

The intention of this project is to design a universal seat which can be used on all aircrafts to ensure people with disabilities can be seated comfortably. This could entail a material of some kind that would take the shape of a person's unique seat of the mobility device, or an adjustable mechanical system can be built in. Then the seat could be put onto the aircraft seat where the passenger can sit more comfortably.

| MECH-13: Design Improvements on a Robotic Spine - Mech. Eng. Students

The spine is one of the major components of the human body which plays a role in the human stability and dexterity. To better understand and examine the problems associated with it such as Lower back pain which is reported to affect around eighty percent of the population, a biomimetic model of the human spine and surrounding tissues is being developed. This project has a focus on creating and integrating reliable soft tissue analogues through the design and fabrication of vertebral discs with a provision for sensor integration and design and fabrication of the thoracolumbar fascia with various force sensors. The project will be concluded with the integration of the above design into the robotic spine

model and evaluation of its functionality.

MECH-14: Expandable Balloon Separator

High altitude balloons are unmanned and usually filled with helium or hydrogen. The balloon carries scientific experiments and payloads that are integrated on a payload gondola to a “near-space” altitude of 18 to 45 km. The main components of the flight train are; Balloon, separator, parachute and Gondola (including payload and subsystem). The purpose of the separator is to detach the balloon from the parachute. The objective of the project is to the design a separator that compatible with our flight train and respect the specifications listed.

| MECH-15: AccuTrack: Guidewire Position Tracking Device Attached to Catheter

This is a medical device development project. The goal is to design a device that is able to track the position of a guidewire as it is inserted back and forth inside a catheter. This device must be manufacturable at a low cost.

| MECH-16: Oscillating Appliance for Postural Correction of TMJ Disorders and Obstructive Sleep Apnea

The temporomandibular joint (TMJ) is the most peculiar joint in the human body. It is a paired joint in which movement occurs simultaneously, but not necessarily symmetrically, on both sides. The hypothesis of this design project is that correction of posture involving reconditioning and relaxation of the hyoid depressors, and also involving protrusion of the mandible, would together abolish the persistent spastic state of all the muscles involved in mandibular movement and restore their appropriate iterative contractile ability, while also unloading the TMJ and dentition. This design project aims at building a prototype of an oscillating appliance for the head and neck area.

| MECH-17: BluBand: Glucose Sensor Transmitter for People with Diabetes

For patients living with diabetes, it is critical that they maintain their glucose levels within an optimal range. The objective of this project is to develop a transmitter capable of transforming short-wave radio frequency into cellular signal that can attach to the glucose monitors worn by diabetic patients. The device must be small, ideally waterproof, and made in such a way that it will clip onto the glucose sensors worn by the children. The device will use a sim card to transmit directly to the cellular signal, so that the device will function even outside of the range of Wifi.

| MECH-18: Design and Development of a Compact Blood Recirculation Assisted Oxygenator

The COVID-19 pandemic and its possible subsequent waves has shown obvious

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needs for ventilation and blood oxygenation. This project is about the development of a compact and easy to use Extracorporeal Membrane Oxygenation (ECMO)-system to treat patients for whom mechanical ventilation is insufficient for life support (and to allow for ambulation). The project's objective is to make the initial design of the pump-micro-hollow fibers technologies (HFM) concept using the hollow pump and incorporation of available micro-hollow fibers. 3D printing of the concept should allow for testing with the existing testing rig.

| MECH-19: Green Powered Mechanical Ventilator

The project consists of designing a low-cost yet efficient mechanical ventilator for use in localities where modern conditions of steady reliable electric grid is not available. The ventilator must be compact and must not require electricity. The device should utilize any energy source readily available such as human power, water current, wind, etc. The main challenge is to design the product with high medical standards while maintaining a flexible range of operation to minimize adverse effects of mechanical ventilation. The technology aims at combining Zeolite materials to enhance O2 concentration and exploit the ventilator rotor concept to generate the needed conception. The Capstone project aims at developing further concepts, optimizing and testing the design for the target operating regime.

| MECH-20: Design Upgrade for a Pediatric Endotracheal Tube Holder

The goal of this project is to design and develop a newer version of a pediatric endotracheal tube holder.

| MECH-21: Lattice Metamaterial Component Development

We developed lattice metamaterials with controllable thermal expansion, i.e. we can manipulate their architecture and material composition to obtain the CTE that we want, including negative zero and positive. The goal of this project is to design and develop an actual component/product with zero CTE and/or morphing capacity (TBD). The application would range from aerospace to household components, such as a house door.

| MECH-22: Multimodal Haptic Armrest

This project investigates simultaneous delivery of haptic stimuli from a heterogeneous set of actuators, embedded in an armrest, in order to generate rich and immersive feedback during a user's engagement with a visual display, e.g., during movie-watching, gaming, or video-based sports training. The target haptic actuation methods include conventional vibrotactile, force-feedback (push-pull impact or gripping), thermal, and pneumatic. These could be exploited, for example, during the falling into the pit scene in Jumanji, by having the armrest convey physical sensations appropriate to the experience of gripping and tumbling, and rapidly reduce the delivered temperature, in order to augment the immersive nature of the viewing experience. The students will design a prototype armrest that embeds several independently controlled haptic

interfaces to realize these objectives.

| MECH-23: 3D Printed Tactile Illusions Design and Evaluation

Appreciating a sensory illusion often requires you to experience it with your own senses. While this is generally trivial for visual and auditory illusions that can be rendered using commonly available hardware, haptic illusions often require complex mechanical systems. Our research group has already created a set of 3D printed tactile illusions. This project involves the refinement of our existing models to strengthen illusion robustness, and the modelling of new 3D printed illusions drawn from the literature. An evaluation and validation of the robustness of the illusions will be carried out through a user study. The candidate may be asked to participate in the submission of an academic paper, which will include literature review, writing, and editing activities.

| MECH-24: Design and Development of a Wearable Percussion Device Aimed at Stimulating Muscles

This project seeks to put forth a novel mechanical design of a wearable mechanism that stimulates local targeted muscle to aid in the post workout (performance) healing process. The widespread adoption of percussion massage devices, such as the Theragun, for example has been a surprise. Nevertheless, such adoption is supported by the notion of triggering or stimulating muscles with a set frequency and magnitude of force can be favorable to stimulation an underlying biochemical response towards healing. This project will seek to achieve such specs (values to be determined by team) with an assembly and fixation methods (to also be designed) to enable a targeted application on the paraspinal and leg muscles.

| MECH-25: Design Improvements on a Robotic Spine - Bioeng. Students

A benchtop robotic spine is being designed and manufactured to act as a model for the movement of a real human spine under different loads. It currently consists of spinal bones, a rib cage and pelvic bones as well as select vertebral muscles; it lacks connective tissues and the majority of its supporting muscles. However, spinal stability relies significantly on the tensile effects of a multitude of non-Newtonian and non-Hookean connective tissues and muscles and as such, it cannot be effectively modeled as a column of bones with a classical Newtonian approach. The thoracolumbar fascia (TLF) is a complex network of connective tissue in the lower back and abdominal regions that is critical for spinal stability and distribution of forces on the spine. To compensate for the spine model's lack of connective tissues, fascial tissues, and muscles, a TLF analogue based on the engineering concept of tensegrity was designed and integrated to the model through a tunable extension spring system. Moreover, seventeen artificial intervertebral discs with reduced stiffness were added to increase the robotic spine model's physiological accuracy.

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| MECH-26: Synchronization of Drive Pistons for Magnetized Target Fusion

Magnetized target fusion (MTF) is a promising concept for fusion energy that—if realized—would be an effectively infinite supply of clean, zero-emission energy. This project will explore techniques to mechanically synchronize the pistons to ensure a perfect implosion. The project will involve significant hydraulic and structural modelling. A prototype with a minimum of three coupled pistons with optical access to the pistons-in-cylinder will be built.

| MECH-27: A Fast Deployable Self-Expandable Portable Flood Barrier

The goals of this project are to design and build a fast, deployable expandable portable flood barrier that can adjust its height with the changing flood water levels. The barrier should be designed to be installed by two persons and to withstand the change of flood water level up to 1 m. The time, cost, and manpower to install the new self-expandable barrier should be reduced by at least 90% in comparison to the traditional sandbag barriers method.

| MECH-28: Design of Manufacturable Electrochemical Cell Test Rigs for Testing Batteries

Electrochemical energy storage (EES), in the form of batteries, supercapacitors, capacitors, or fuel cells, stands as a viable pathway to electrification of the energy economy at all size scales, from the entire power grid to handheld phones. As Canada moves to diversify its energy portfolio in the large-scale grid, it must also diversify how energy is stored to ameliorate the intermittency and irregularity of renewable resources. The goal of this project is to design cells for the electrochemical test rig to increase the mechanical stability in testing. The cell will be designed based off common glass vessels. The design must fit and work well with the current testing system, use appropriate materials based on different electrolytes and electrodes tested, and be reusable. The rig will be designed and machined for testing, while taking into account manufacturability, as multiple test rigs (about 2 dozen) need to be designed and duplicated.

| MECH-29: COVID-19 Rapid Diagnostic Platform Utilizing Ultralow-Cost, Electricity-Free Centrifugation

Point-of-care diagnostic devices for detecting COVID-19 are vital to accelerating large-scale testing of the infection quickly and at decentralized settings. In this project, we aim to develop an ultralow-cost, ratchet-based centrifugal solution assembled using 3D-printed and rapidly-prototyped components, that can be operated in a user-friendly, electricity-free manner to conduct rapid diagnostic tests on microfluidic chips. Further on, integration of the novel centrifugal component with open-source auxiliary elements, including portable heaters and smartphone-based imaging apparatus, will be explored to produce a fully standalone, on-field diagnostic platform. Finally, the device prototype will be applied towards point-of-care quantitative detection of COVID-19, either via implementation of isothermal amplification-based nucleic acid assays or microarray-based immunoassays.

PROJECT ABSTRACTS

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| MECH-30: Improved Surgical Drain

Surgical drains are placed after a variety of different surgeries in a variety of different specialties including orthopaedics and general surgery. In this project we propose to redesign the drain attachment mechanism. This will allow for quick drain installation during surgery and allow for easy removal. This innovation would be transferable to all drains used in the operating rooms. Another aspect of innovation will be to redesign the succion and fluid collection container to allow patient to be mobile even if large amount of fluid is excreted from their wound.

| MECH-31: Optimization of Cryobiopsy Accessory Fabrication

Lung biopsy is used to remove pulmonary tissue in a minimally invasive manner from patients in order to diagnose interstitial lung disease. Current methods for performing this procedure are risky and sub-optimal, and a novel solution is being developed to improve patient safety and ease of use.

The objective of the project is to develop tooling to optimize the fabrication of a key accessory component of the novel lung biopsy device.

| MECH-32: Bladeless Fan

Creating a suction effect by creating a pressure difference across a cylindrical shaped model. The pressure difference will force the flow of air to go from the high-pressure region to the low-pressure region. That is applied by using a cylindrical shaped model that has holes with different sizes, which will increase the velocity of the flow of air and hence will cause a pressure drop (Bernoulli's). The ambient air below the cylindrical model, that is at the atmospheric pressure, will be sucked into the model to the other side.

| MECH-33: Design of a Spinning LIDAR for Autonomous Drone Mapping

The Unmanned Aerial Vehicles (UAV) industry has boomed over the past decade, seeing increased applications in sectors such as shipping and delivery, geographic mapping, aerial photography and disaster management. The project at hand is to design and manufacture a mechanism capable of spinning a laser-based range sensor (LIDAR) sensor at a constant rate. The mechanism must be lightweight, compact, modular, and easily mountable on a drone. Additional aspects to consider is how to incorporate a slip-ring in order to transmit power across the rotating mechanism and how to use encoder feedback to accurately estimate the orientation of the spinning LIDAR at any moment. Once complete, correct data acquisition must be verified. Additionally, software must be written to "de-skew" the raw LIDAR data so that it can be used in algorithms running onboard the drone.