TRANSFORM HF Undergraduate Summer Research Program

The TRANSFORM HF Undergraduate Summer Research Program (USRP) gives students the opportunity to train alongside our multidisciplinary community of researchers to help address the grand challenge of inequity in heart failure care.

Students participating in the USRP will receive an award of up to $6,000, which must be supplemented by a $2,000 contribution from their research supervisors to ensure a minimum total stipend of $8,000 for a period of 16 weeks.

To be eligible, students must be registered at a Canadian academic institution as a full or part-time undergraduate student at the time of application. Up to two USRP awards are reserved for Indigenous students.

To apply, students must secure two faculty supervisors within TRANSFORM HF (one of which must be Faculty of Applied Science and Engineering (FASE)-affiliated), and work with them to complete and submit an application. To facilitate this process, students may either:

- Consult the following list of established projects seeking an undergraduate summer student, and reach out to the associated supervisor for more information.

  OR

- Consult a list of faculty within the TRANSFORM HF network, and reach out to faculty members directly to inquire about potential projects. FASE faculty are highlighted in yellow.

If students wish to work with supervisors who are *not* already a TRANSFORM HF member, the supervisor must join the network in order for the student to apply for this opportunity.

Applications are due March 9, 2025 at 5:00pm EST.

1. SMART TEXTILES FOR MONITORING AEROBIC FUNCTION

Placement Duration
16-week from May-August 2025

Placement Location
University Health Network, KITE Toronto Rehabilitation Institute

Project Description
This project aims to create smart textiles that monitor heart and lung activity to help improve care for people with heart conditions. These textiles will use sensors to measure oxygen uptake (VO2), a key indicator of fitness and heart health. By combining advanced fabrics with artificial intelligence, we can make it easier to track aerobic function outside the lab, including during rehabilitation programs. The goal is to develop a comfortable, easy-to-use garment that provides accurate health information. The results will help improve patient care and enable remote monitoring for cardiac rehabilitation.

Requirements
- Current undergraduate or graduate student in biomedical engineering, electrical engineering, computer science, or a related field.
- Experience with Python or MATLAB for data analysis.
- Interest in working with wearable technology or medical devices.
- Strong communication and attention to detail.

Contact Information
This project will be co-supervised by Dr. Azadeh Yadollahi. Please contact Delaram Sadatamin for more information (delaram.sadatamin@mail.utoronto.ca)

2. SMART SOCKS & SLEEVES FOR MONITORING EDEMA

Placement Duration
16-week from May-August 2025

Placement Location
University Health Network, KITE Toronto Rehabilitation Institute

Project Description
This project focuses on developing smart socks and sleeves to monitor fluid buildup (edema) in patients. These wearable devices will use textile-based sensors and machine learning to measure and track fluid changes in the body. Key tasks include designing the sensors, testing them against existing medical tools, and running data collection sessions to ensure accuracy and ease of use. The project will help improve remote healthcare monitoring for patients with chronic conditions.

Requirements
- Current undergraduate or graduate student in biomedical engineering, electrical engineering, computer science, or a related field.
- Experience with Python or MATLAB for data analysis.

- Interest in working with wearable technology or medical devices.
- Strong communication and attention to detail.

Contact Information

This project will be co-supervised by Dr. Azadeh Yadollahi. Please contact Delaram Sadatamin for more information (delaram.sadatamin@mail.utoronto.ca)

3. BI-AXIAL TENSILE TESTING APRON MECHANISMS FOR CARDIOVASCULAR TISSUE SYSTEMS & DEVICES

Placement Duration

May 1, 2025 to August 29, 2025

Placement Location

Mechanical & Industrial Engineering Building, University of Toronto (CRAFT).

Project Description

Viscoelastic tissues, such as those primarily composed of collagen type I, exhibit multidirectional deformation characteristics and are nearly incompressible under mechanical stress. These tissues function under complex multi-axial loading conditions, encompassing tensile, compressive, and shear forces. To accurately characterize the biomechanical properties of such materials, biaxial tensile testing is indispensable, as it enables the measurement of deformation along both orthogonal tensile and shear loading axes. However, the mechanical assessment of these tissues presents significant challenges, primarily due to the typically small dimensions of the sample specimens. The gripping of these specimens often necessitates the use of specialized tools, such as clamps, rakes, or sutures, which require puncturing the edges of the gauge region — thereby complicating precise and accurate measurement. To mitigate the risk of structural damage, while ensuring stable and reproducible measurements, an apron is strategically employed around the gauge region, stabilizing the specimen and facilitating reliable data acquisition.

The Guenther laboratory has recently developed a microfluidic fabrication technique for producing ultra-thin (2-micron) collagen type-I sheets, which feature tunable anisotropy, robust directional fibrillar alignment, and d-periodic banding. The objective of this summer research project is to systematically characterize the biaxial tensile properties of these collagen sheets, providing essential insights into their mechanical stability and applicability in tissue engineering and biofabrication for cardiovascular applications. The student will perform these experiments using various custom apron devices on a commercial CellScale BioTester system. Key mechanical parameters, including elastic modulus, ultimate tensile strength, and strain at failure, will be evaluated and reported alongside resulting stress-strain curves. The goal is to identify the most effective apron design — one that minimizes damage to the collagen sheets while ensuring precise tensile measurements. This work will contribute significantly to the development of tissue engineered structures and devices for cardiovascular medicine.

Requirements

- Upper year student (3rd year +)
- Experience with computational modelling software such as Ansys is preferred but not required.
- Experience and/or evidence towards a passion for tissue engineering is welcomed.

Contact Information

This project will be co-supervised by Dr. Axel Guenther. Please contact Chantel Campbell for more information (chantelbriana.campbell@mail.utoronto.ca)

4. ALGORITHM DEVELOPMENT ASSISTANT

Placement Duration

May 1, 2025 to August 30, 2025.

Placement Location

This is a hybrid role and would require travel to Mount Sinai Hospital on an as-needed basis. However, most of the work will be conducted remotely.

Project Description

One in four heart failure (HF) patients admitted to hospitals dies within one year. Patients are instructed to monitor their condition at home after returning home from the hospital, but this strategy has been marginally successful due to patients not keeping up with the frequency of the measurements and interpreting the results. The Cardiac Catheterization Research Laboratory (CCRL) at Mount Sinai Hospital is testing SmartTile, an unobtrusive and autonomous care solution that monitors the patient during sleep without wearable or any contact with the body. The core technology tested is a bio-signal known as a ballistocardiograph (BCG). The clinical collaborator, Dr. Susanna Mak, is a renowned HF physician, and the research team will work as part of Dr. Mak's laboratory. The scientific advisor of the project is Dr. Alex Mihailidis.

The position will involve active participation in ongoing BCG research. The successful candidate will support the supervisor, Dr. Isaac Chang, and will assist in the analysis of BCG via signal processing and algorithm development. The intern will work with Dr. Chang to process the data collected from human participants and will assist in developing signal processing and, potentially, machine learning algorithms. Specifically, the intern can expect to:

- Assist the primary project lead, Dr. Isaac Chang, in analyzing physiological data using Python libraries, including but not limited to Numpy, Pandas, Scipy, Scikit-learn and Matplotlib. MATLAB is also used in the analysis. Primary development will be done in a collaborative environment.
- Clean acquired data for analysis via filtering and resampling
- Contribute to statistical analysis and machine learning algorithm development
- Optimization of written codes and modularization into functions

- Administrative and logistic tasks involved in research, including but not limited to the documentation of research protocol, literature review, and write-up of manuscript sections for publication.
- Assist data collection and conduction of research trials
- Participate in a weekly meeting with the supervisor
- Prepare reports and presentations based on the work done

Requirements

- Must have an engineering or computer science background
- Experience working with Python libraries: knowledge of Numpy, Pandas, Scipy or Scikit-learn, and Matplotlib is required
- Basic knowledge of machine learning algorithms such as logistic regression, basic neural networks, and an understanding of supervised/unsupervised models is not required but helpful
- Strong team collaboration
- Strong problem-solving skills in the context of solving algorithmic problems
- Strong oral and written communication skills and interpersonal skills

Contact Information

This project will be co-supervised by Drs. Susanna Mak, Alex Mihailidis, and Isaac Chang. All applications should include an unofficial academic transcript and resume, and be sent directly to Dr. Isaac Chang (isaac.chang@mail.utoronto.ca) with the following subject:

Applicant's name – Summer 2025 Algorithm Development Assistant Application

Due to the large number of expected applications, only the candidates who have been selected for the interview will be contacted.

5. INTEGRATING LARGE LANGUAGE MODELS IN VIRTUAL CARDIAC REHABILITATION FOR MEASURING AND ENHANCING HEART-FAILURE PATIENT ENGAGEMENT

Placement Duration

May 5, 2025 to August 25, 2025.

Placement Location

University Health Network, KITE Toronto Rehabilitation Institute

Project Description

Following discharge from acute care after a heart failure event or procedure, patients are often referred to cardiac rehabilitation programs. These interdisciplinary interventions improve physical, psychological, and social well-being, reducing re-hospitalization and mortality by up to half. Despite these benefits, dropout rates can reach 50% due to several barriers, including low confidence and engagement—often stemming from limited self-efficacy, perceived program relevance, and insufficient support. Cardiac rehabilitation can be delivered virtually or in person with comparable effectiveness, with educational sessions serving as a key component of the program. These sessions focus on balanced nutrition, active lifestyles, stress management, and avoiding harmful behaviors, equipping patients with the knowledge and skills needed for long-term health.

Engagement in virtual cardiac rehabilitation enhances patient satisfaction, performance, adherence, and recovery. However, measuring engagement in group settings remains challenging. While AI shows promise for large-scale engagement measurement, methods tailored to telehealth remain limited, particularly for patients and older adults. Existing approaches often overlook the learning context and the evolution of engagement across consecutive sessions. To address this gap, the research team collected and annotated a novel dataset from eleven heart failure patients participating in virtual cardiac rehabilitation educational sessions over a six-week period. The sessions, recorded via Microsoft Teams, generated 35 hours of data—the largest engagement estimation dataset to date.

This project aims to develop a deep-learning framework leveraging large language models for context-aware patient engagement estimation in virtual cardiac rehabilitation. Using advanced tokenization techniques, the framework integrates participants' affective, behavioral, and cognitive states with contextual information from virtual sessions to train large language models for engagement inference. Beyond detecting engagement, the framework predicts engagement levels, enabling clinicians to intervene proactively. The methodology will be validated on the collected dataset. By predicting and enhancing engagement, the framework aims to sustain participation, improve outcomes, and boost adherence to virtual cardiac rehabilitation programs. Ultimately, these efforts aim to reduce re-hospitalization and mortality rates through timely and targeted interventions.

Requirements

Candidates for this role must be students in computer science, electrical engineering, biomedical engineering, or a similar discipline, with experience in applying deep learning algorithms to human emotion and activity recognition, including graph convolutional networks and Transformers, and proficiency in fine-tuning large language models. The selected student's primary duty will involve the development of deep learning models.

Contact Information

This project will be co-supervised by Drs. Shehroz Khan and Travey Colella. Please contact Dr. Khan for more information (shehroz.khan@uhn.ca).

6. POINT-OF-CARE TOOL DEVELOPMENT FOR RAPID & ACCESSIBLE DIAGNOSIS OF HEART FAILURE

Placement Duration

16-week from May-August 2025

Placement Location

Department of Chemical Engineering & Applied Chemistry, University of Toronto

Project Description

Heart failure (HF) is a global burden that particularly impacts populations that face barriers in accessing proper tools and healthcare services, leading to delayed diagnosis and poor prognosis. Irregular expression and function of circulating microRNAs (miRNAs) has been linked to poor prognosis in HF. Current methods for measuring miRNA expression profiles are labor-intensive, costly, and require specialized equipment, limiting their accessibility.

This project aims to leverage CRISPR technology to develop a low-cost, portable diagnostic tool that will overcome these limitations by enabling rapid detection of miRNAs at the point of care. The initial stages will involve designing and testing programmable sensor technologies for the sensitive detection of miRNAs. These designs will be optimized to ensure sensitivity, specificity, and reproducibility. Quantification and multiplexing capability will then be incorporated into the designs, extending detection to a panel of clinically relevant miRNAs. Finally, the designs will be developed and validated in low-cost, scalable, and portable formats, such as a lateral flow strip, for point-of-care use. This diagnostic platform aims to make HF diagnostics more efficient, sustainable and accessible, and will have the potential to extend to other diseases, offering an adaptable solution to improve global healthcare equity and outcomes.

Requirements

Current full-time undergraduate student, preferably with experience with or an understanding of laboratory techniques such as PCR and fluorescence detection methods.

Contact Information

This project will be co-supervised by Dr. Nicole Weckman. Please contact Dr. Weckman for more information (nicole.weckman@utoronto.ca).