



Open Graduate Research Projects

Please review a sample of current Open Graduate Research Opportunities in MME. Please reach out to faculty members for more information.

Energy and Fluid Systems

Dr. Jackson Crane (jackson.crane@queensu.ca)

Field: Thermodynamics

Dr. Jackson Crane is interested in renewable energy conversion technologies, electrocatalysis, and low-carbon combustion. His current research focuses on detonation fundamentals with application to high-efficiency engines. He is also active in the area of alternative fuel synthesis via CO₂-reduction electrocatalysis. For more information, see his lab website:

<https://craneresearch.com>

MASc positions are available for experimental research in supersonic combustion with application to high-efficiency engines. Projects include studying liquid-spray detonation and controlling detonation instabilities.

Dr. Ugo Piomelli (ugo@queensu.ca)

Field: Computational Fluid Dynamics

Graduate Opportunities in Turbulence Simulation and Modelling Laboratory (TSM Lab) where Professor Piomelli and his collaborators are developing new methodologies to enable the analysis and prediction of turbulent flows, and applying these methods to study the physics of turbulence in real-life applications.



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Dr. Barbara da Silva (Barbara.dasilva@queensu.ca)

Field: Fluid Dynamics and Heat Transfer

The Flow, Wakes and Energy Research Lab ([FloWER Lab](#)) studies the complex wake flows that are formed around obstacles like buildings, rotors, vehicles, vegetation canopies and electronic components. Led by Prof. Barbara da Silva, the group combines experimental methods and computational fluid dynamics (CFD) simulations to investigate the fundamentals of these flows and explore ways we can apply them (or improve them) in applications in wind engineering, energy and biological systems.

<https://bdasilva.smithengineering.queensu.ca/>

Graduate Research Projects

Project 1: Wake patterns in pulsating flows

Most engineering and biological applications feature unsteady flow conditions, whose effects on the wake of obstacles are not very well understood. Motivated by blood flow applications, students will combine computational fluid dynamics (CFD) simulations and experimental measurements using optical techniques to discover the effects of a pulsating inflow on wall-mounted obstacles.

Project 2: Wake interference effects in heat transfer enhancement

Electronic components and heat sinks can be modeled as arrays of wall-mounted finite bodies, for which wake proximity and interference effects are complex and demand further investigation. The objective in this project is to investigate the flow regimes that arise depending on how the bodies are arranged, possibly informing the design of improved configurations to enhance mixing and heat transfer.



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Dr. John Kurelek (john.kurelek@queensu.ca)

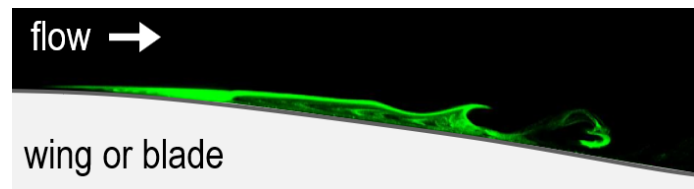
Field: Fluid Dynamics

Professor John Kurelek's research group focuses on advancing wind energy and other renewable energy and fuel saving technologies through the study of aerodynamics. We specialize in experimental fluid mechanics, using a range of facilities and cutting-edge measurement techniques to study the flow physics of individual components (e.g., wings, blades, and rotors), and fully integrated systems (e.g., aircraft, wind turbines, and wind farms).

Graduate Research Projects

Project 1: Airfoil boundary layer transition and separation at low Reynolds numbers

The aerodynamic performance of airfoils, the two-dimensional sections that make up aircraft wings and wind turbine blades, is strongly influenced by the state of their boundary layers. Achieving efficient operation at low Reynolds numbers, typical of low-speed aircraft and small wind turbines, presents significant challenges, as boundary layers tend to remain laminar and thus are highly susceptible to separation, leading to reduced lift and increased drag.



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Our work has shown laminar separation bubbles (LSBs) play a critical role in this regime. An LSB forms when flow separates from the airfoil surface, transitions to turbulence and reattaches downstream, partially recovering performance. However, this leaves the flow in an unstable configuration, as even slight changes in the environment or operating conditions can lead to the LSB 'bursting' and the sudden onset of stall.



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This project aims to investigate the mechanisms of boundary layer transition and separation on airfoils at low Reynolds numbers, with a focus on the formation and dynamics of laminar separation bubbles. The research will be conducted through experimental means, making use of the Optical Towing Tank for Energetics Research (OTTER).

References: [Kurelek et al. 2018](#), [Kurelek et al. 2021](#)

Project 2: Active flow control for wind turbine blades

Wind turbine blade design requires a careful balance between aerodynamic efficiency, structural integrity, and cost. To meet structural demands near the hub, relatively thick airfoil sections are typical in the root region, where relative flow velocities are low. This makes the root region prone to flow separation that reduces overall power output.



Our research in active flow control using plasma actuators has demonstrated their effectiveness in controlling separated flows. These actuators can be used to either inject momentum directly into the near-wall region upstream of separation or accelerate transition within the separated shear layer by amplifying natural instabilities. A physics-informed control strategy, guided by knowledge of the boundary layer state, is essential to maximize control authority and effectiveness.

The goal of this research project is to evaluate active flow control strategies for aerodynamic performance improvement of wind turbine blades, with a focus on mitigating separation in the root region. The work will be conducted experimentally and will involve the design, fabrication, and wind tunnel testing of plasma actuators integrated into representative wind turbine blade models.

References: [Kurelek et al. 2023a](#), [Kurelek et al. 2023b](#)



Open Graduate Research Projects

Biomechanics and Robotics

Dr. Heidi-Lynn Ploeg (heidi.ploeg@queensu.ca)

Field: Biomechanics

Queen's Bone and Joint Biomechanics (Q-BJB) Lab focuses on developing biomechanical solutions for the prevention, care and treatment of diseased or injured bones and joints.

Located within the Kingston Health Sciences Centre (KHSC), the Q-BJB Lab is in a prime location for collaborative research work with the hospital. Research approaches include mechanical testing and computational modelling of bone and orthopaedic implants.

- Aid the development of biomechanical and safe solutions for the prevention, care, and treatment of diseased or injured bones and joints.
- Improve understanding of the human musculoskeletal system.
- Create an inclusive, inspiring, and supportive learning environment for trainees.
- Provide resources for trainees to complete innovative research work.
- Implement a collaborative research model to find comprehensive biomechanical and safe solutions to complex problems.

<https://www.queensu.ca/ploeg-bone-joint-research/>

Open Positions for those with an interest and willingness to learn about bone and orthopaedic implant biomechanics, mechanical testing, computational modelling. Good at working and communicating in teams.



Open Graduate Research Projects

Dr. Qingguo Li (ql3@queensu.ca)

Field: Biomechanics and Robotics

At the Bio-Mechatronics and Robotics Lab (BMRL), we integrate modeling, mechatronics system development and design optimization as well as human experiments to innovate biomechanical energy harvesters, exoskeletons, load carriage systems, and accessible technologies for human movement analysis. www.bmrlab.ca

Graduate Research Project

Project: Exoskeleton Development

The Bio-Mechatronics and Robotics Laboratory (BMRL) is seeking a graduate student to contribute to an innovative project focused on developing energy-autonomous lower-limb exoskeleton solutions. This research aims to enhance real-world mobility, particularly for individuals facing mobility challenges, such as the elderly and those carrying heavy loads (e.g., soldiers and first responders).

Our program investigates inter-limb cross-joint exoskeletons that integrate energy harvesting with active assistance to significantly reduce the metabolic cost of walking while minimizing reliance on external power sources. Building on our recent pioneering work, we have demonstrated that controlled braking at the knee during the late swing phase of walking can reduce metabolic costs by 2.5% and generate free electricity (0.25W), challenging the traditional notion that exoskeletons must inject power to provide benefits.

As a research assistant, you will play a key role in biomechanical system modeling and design, prototyping and testing, instrumentation development, data collection, and analysis of biomechanical measurements related to exoskeleton performance. This position offers the opportunity to contribute to high-impact research aimed at improving the quality of life for individuals with mobility limitations.



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Dr. Amy Wu (amy.wu@queensu.ca)

Field: Biomechanics and Robotics

The Biomechanics x Robotics Laboratory (BxRL) is at the intersection of human biomechanics and robotics with the aim of building better assistive technologies. Researchers are interested in utilizing a first-principles approach to understand the mechanics and energetics of human movement (locomotion and balance) and to apply those principles to robots. Likewise, they leverage robots to reveal the mechanisms behind human behavior and to further investigate human-robot interaction. The lab is also passionate about using maker-style manufacturing techniques to build impactful, openly available robotic devices for both research and education.

Graduate Research Projects

Currently looking for suitable Master's and PhD students for the following projects (tasks will be scaled based on degree program)

Project 1: Design of infant feeding assistance that maintains the mother-baby dyad. Tasks include:

- Co-develop a sensor and actuation system for infant supplementary feeding (ideally wearable)
- Attend co-creation group meetings and consult medical professionals to determine functional/engineering requirements
- Design and fabricate fluidic control, regulation, and sensing mechanisms, and combine into an integrated wearable system
- Technically analyze and assess the integrated systems
- Iterate and adapt designs/prototypes according to medical team experts and experimental results



Open Graduate Research Projects

Project 2: Design of a real-time measurement system for fall risk detection during walking across different terrain over long periods of time.

Tasks include:

- Development of a multi-sensor wearable measurement system that provides physiological information about the wearer's gait and balance. The measurement system will be validated with in-lab motion capture systems to determine the accuracy and reliability of relevant measures.
- Multi-season outdoor data collection to measure real walking conditions with the measurement system over a long period of time.
- Development of a balance model that can be validated by the data and leveraging the model to make a prediction of fall risk and corrective behaviors.

Project 3: Design of a trunk exoskeleton that can provide both haptic and active feedback for fall prevention.

Tasks include:

- Incorporating appropriate haptic cues to indicate behavior corrections are needed.
- Designing a system that can move the trunk to physically correct behaviors that increase fall risk.
- Leverage the results from the real-time measurement system to design an appropriate controller and correction mechanism.
- Evaluate the efficacy of the two assistive modes (haptic vs active) with human studies.
- Validate the trunk exoskeleton with human studies.



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Design and Manufacturing

Dr. Il Yong Kim (kimiy@queensu.ca)

Field: Systems Design

The Structural and Multidisciplinary Systems Design Group (SMSD) at Queen's University is lead by Dr. Il Yong Kim in the Department of Mechanical and Materials Engineering, who supervises over 25 graduate students working with multiple industry partners in the aerospace, automotive, energy, and defense sectors, including Bombardier, Pratt & Whitney Canada, De Havilland Canada, General Motors, Magna, Safran, General Dynamics. Dr. Kim's lab specializes in advanced research topics focused on finite-element analysis, design optimization, and machine learning including topics in: multi-material topology optimization, design for additive manufacturing, carbon fibre reinforced plastic and packaging optimization.

<http://ilyongkim.ca/>

Graduate Research Projects

Project 1: Finite element analysis and lightweight design of aerospace and automotive systems

Project 2: DfAM (design for additive manufacturing) for automotive & aerospace lightweight design

Based on design optimization and topology optimization, the project will conduct multi-physics modeling, analysis, and design optimization of parts & assemblies considering metal & polymer additive manufacturing, with applications in automotive and aerospace design.



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Project 3: Carbon fibre reinforced plastic (CFRP)-based lightweight design for automotive & aerospace structures

Achieve lightweight and cost-effective designs for automotive & aerospace parts, considering modeling and optimization of the number of layers, stacking sequences, fibre orientation, geometry, and joining methods.

Project 4: Machine Learning-based optimization for energy and aerospace industries

Develop hybrid design optimization methods based on machine learning and standard optimization, for rapid and effective simulation and design of hydro-turbine systems and aerospace systems.



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Materials

Dr. Laurent Béland (Laurent.beland@queensu.ca)

Field: Computational Materials Science

Dr. Béland's group use **supercomputers and artificial intelligence (AI)** to understand how materials behave under different conditions. We look at everything from **nuclear alloys and ceramics** to **minerals, catalysts, and bone-like materials**. The goal is to design materials that are stronger, cleaner, and longer-lasting. I enjoy working at the intersection of **materials science, computing, and physics**, where we can connect what happens at the atomic scale to real-world challenges in energy, the environment, and health.

Graduate Research Opportunities (MAsc and PhD)

I'm looking for graduate students who are curious about how **computers and AI can help design better materials**. Current and upcoming projects include:

- Using **machine learning** to predict material properties.
- Modeling how **metals, semiconductors, and ceramics** evolve under heat or radiation.
- Developing new **simulation tools** for corrosion, fracture, and catalysis.
- Applying **supercomputing** to study materials for **nuclear, environmental, and energy systems**.

Students in my group gain hands-on experience in **high-performance computing**, programming, and data analysis, while contributing to real-world challenges in clean energy and materials design.

Dr. Béland welcomes conversations with potential students to develop a project that fits both the **research program's goals (and sponsors' priorities)** and the **student's own interests and career objectives**. Many opportunities exist for **industry or international internships** as part of this training.



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Dr. Mark Daymond (mark.daymond@queensu.ca)

Field: Nuclear Materials

The Reactor Materials Testing Laboratory (RMTL) is a state of the art, one-story facility that was officially opened in 2015. The facility includes a proton and helium accelerator to introduce radiation damage and transmutation products into materials, mimicking the changes to materials occurring in a nuclear reactor. <https://rmtl.engineering.queensu.ca/>

Graduate Research Project

Project: Design, Build and Test experimental equipment

The Mechanics of Nuclear Materials group at Queen's looks after RMTL, a state of the art accelerator facility. With it, we can introduce radiation damage into materials, emulating what happens inside a nuclear reactor. It's a large and active team, with lots of opportunities to work with industry and travel. We are looking for both graduate students and undergraduates for a summer, with openings for those

- interested in materials degradation, mechanical testing and/or electron microscopy
- wanting to design and build components for the accelerator facility. That would include mechanical design and control (e.g. Arduino) aspects



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Dr. Yanwen Zhang (yanwen.zhang@queensu.ca)

Field: Materials Science and Radiation

Dr. Zhang is a Professor and Canada Excellence Research Chair in Impact of Radiation in Energy and Advanced Technologies. A recognized leader in materials science, her research explores how materials behave under extreme conditions, with a focus on defect dynamics, ion beam modification, and radiation effects. Her research emphasizes how these processes can be harnessed to tailor the properties and functionality of complex materials for extreme environments.

Graduate Research Projects

Project 1: Stability of Nanocrystalline Metal Alloys under Ion Bombardment

Nanocrystalline materials are known for their superior radiation tolerance, owing to their ultrafine grain structures and dense grain boundaries that act as defect sinks. This project explores how nanostructured metal alloys, including complex systems such as high-entropy alloys (HEAs) with multiple principal elements, respond to energetic ion bombardment that is commonly used to simulate radiation damage in nuclear environments.

Ion irradiation is widely adopted in research because it offers precise control over energy, dose, and depth of penetration, enabling accelerated studies of radiation effects without making the samples radioactive. This approach allows researchers to mimic key aspects of neutron-induced damage in a safe and efficient way. Importantly, there are no radiation safety concerns for the intern involved in this project, as irradiation is conducted at dedicated facilities and only non-radioactive materials are handled in the lab.

The students will join an interdisciplinary research team studying the microstructural stability of nanocrystalline alloys under irradiation. The project aims to understand how chemical complexity and nanoscale



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structure influence radiation-induced grain growth and defect evolution, including the contributions from both atomic collisions and electronic excitations.

Project 2: Ion-Induced Grain Growth and Interface Stability in Nanostructured Ceramic Materials

Nanostructured ceramics are gaining attention for use in extreme environments, such as nuclear reactors and space systems due to their potential radiation resistance. Their dense grain boundaries and nanoscale defect sinks can absorb radiation-induced defects, enhancing stability. However, under energetic ion irradiation, even these materials can experience grain growth, interface instability, and microstructural evolution, phenomena that remain only partially understood. This project investigates how energetic ions deposit and dissipate their energy in nanostructured ceramics and how these processes influence grain boundary and interface stability. The focus will be on model systems including nanocrystalline zirconia (ZrO_2), zirconium nitride (ZrN), silicon carbide (SiC), and carbides such as titanium carbide (TiC), zirconium carbide (ZrC), and their solid solutions ($\text{Zr}_x\text{Ti}_{1-x}\text{C}$). These materials offer an ideal platform for studying the entangled effects of electronic energy loss (via inelastic thermal spikes) and nuclear energy loss (via elastic collisions).



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Project 3: Exploring Elemental Complexity in Advanced Structural Alloys for Enhanced Radiation Resistance

Are you a motivated and talented student looking for an exciting research opportunity? Join us to work on this cutting-edge study of advanced structural alloys, specifically concentrated solid solution alloys (CSAs) and high entropy alloys (HEAs). These materials are known for their superior radiation resistance and structural stability in extreme environments. During this project, you will explore the distinctive properties of CSAs and HEAs, which are formed near the centers of phase diagrams. Unlike dilute alloys found at the corners of phase diagrams, CSAs involve interactions between multiple alloying elements, resulting in unique characteristics. At the electron level, disordered local chemical environments enhance scattering processes, impacting electrical and thermal conductivities. At the atomic level, site-to-site lattice distortion and complex energy landscapes influence defect migration and atomic transport.

You will have the opportunity to use different ion beams to create and measure displacement damage, studying the coupled electronic and atomic effects. Ion beams offer a unique perspective on how pronounced ionization effects alter atomic processes and modify defect dynamics. Historically, ionization effects in metals have been overlooked, but this project aims to investigate their significant impact on strain relaxation, damage recovery, and grain growth in complex alloys. Through a combination of experiments and simulations, you will gain insights into the complex correlations between energy deposition, dissipation, defect dynamics, and structural stability. The focus will be on understanding how tunable chemical complexity in CSAs can be applied to modify energy dissipation processes and understand associated defect dynamics. This project aims to understand elemental complexity in complex alloys and improve their radiation performance, ultimately leading to a new design paradigm for creating alloys with enhanced radiation tolerance.



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Project 4: Exploring High-Entropy Materials for Advanced Technologies

Today's technologies rely on an increasingly complex palette of materials, with individual materials made from increasingly complex mixtures of chemical elements. Extreme conditions, such as high temperature, high current, high pressure, and high radiation environments, can push materials from thermal equilibrium to far-from-equilibrium and pose unique challenges in predicting their performance.

Understanding how chemical disorder can be utilized to tailor physical properties, enhance or control energy transport, and improve irradiation tolerance is key for advanced technology applications. This project focuses on high-entropy materials (HEMs), which consist of multiple principal elements creating chemical disorder. More specifically, composition complexity in HEMs gives rise to local chemical disorder and a diverse range of tunable bonding environments that are not typically possible in conventional materials. Substitution disorder is expected to modify defect dynamics and energy dissipation processes. Despite the potential of these materials, there is a lack of systematic studies on the relationship between composition, structure, and properties. Chemical disorder in HEMs and the associated physical properties (e.g., electrical resistivity, thermal conductivity, and thermal expansion) have yet to be fully understood. A detailed characterization of elemental distribution, the accompanying electronic structures, and lattice distortion, as well as the corresponding scattering mechanisms and energy transfer, are crucial in determining the impact of various elemental species. This project aims to reveal the atomic and/or electronic structure responsible for differences in HEM properties. Such knowledge of chemical disorder and element substitution will lead to the design of complex materials with specific functionality and improved performance, thus opening numerous exciting research directions in materials science and offering opportunities for materials discovery.