Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

MIE498H1: Research Thesis 2025-2026

Supervisor	Axel Guenther
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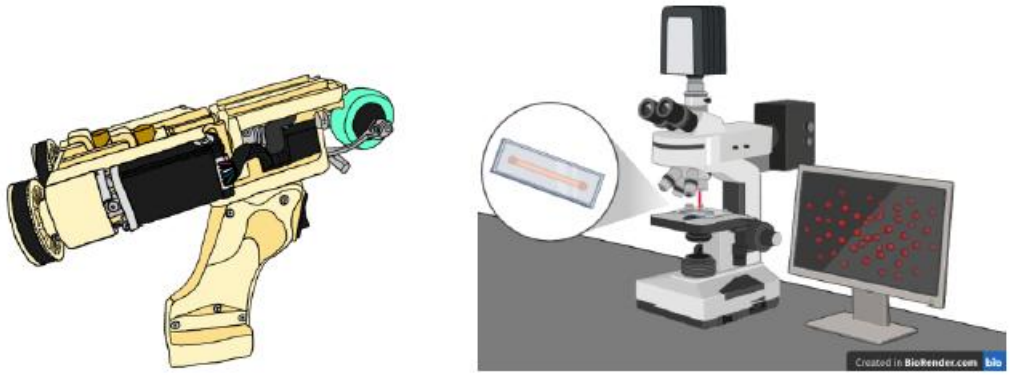
Number of Positions	1
Open to	Mechanical Engineering Students
Term Offered	Full-year
Research Area	Mechanics & Design
Research Topic	Optimizing the in-situ delivery of granular bioinks for promoting the healing of burn wounds

Project Description

This thesis project focuses on optimizing the in-situ delivery of granular bioinks for promoting the healing of burn wounds [1,2]. This granular bioink consists of an aqueous fluid phase and densely packed microparticles, which are delivered directly to the wound bed through a microfluidic printhead. Their non-Newtonian properties and shear-thinning behaviour, where when force is applied, the viscosity decreases and material flows and when left standing, it behaves similarly to a solid, make them an ideal candidate for a bioink that provides high feature fidelity [3].

However, the consistent delivery of such granular bioinks [3,4] using pressure-driven flow through either single-nozzle or multinozzle printheads is challenging due to clogging and inconsistent flow distribution. To systematically assess the flow distribution, we thoroughly investigate both the rheological behaviour using a rheometer and the spatiotemporal velocity field in single-channel flow with vibration using a microscale Particle Image Velocimetry (PIV) technique [5,6]. In addition, the printhead design will be modified to allow for the time-resolved measurement of the pressure and vibration inside the printhead during extrusion. A collaborating graduate student in our laboratory will prepare, characterize and provide you with microgel particles.

The outcomes of your thesis are expected to provide quantitative guidelines for the delivery of granular bioinks through a wide range of extrusion bioprinting systems.



A B

A: handheld bioprinter [1-3], **B:** Micro PIV set up [5-6] granular flow through a single channel

Literature

[1] Cheng *et al.* 2020 “Handheld instrument for wound-conformal delivery of skin precursor sheets improves healing in full-thickness burns” *Biofabrication* **12**, 025002
[2] Hakimi *et al*. 2018 “Handheld skin printer: *in situ* formation of planar biomaterials and tissues” *Lab Chip* **18**, 1440-1451
[3] Singh, Wei, Samiei *et al*. 2025 “Conformal Bioprinting of Bi-phasic Jammed Bioinks, Independent of Gravity, Orientation, and Curvature” https://doi.org/10.1101/2025.05.16.654553
[4] Singh *et al.* 2024 “Scalable preparation of macroporous collagen microgels by air bubble-induced breakup and ice templating” *React. Chem. Eng.* **9**, 2584-2598
[5] Santiago *et al.* 1998 “A particle image velocimetry system for microfluidics” *Exp. Fluids* **25**, 316-319
[6] Meinhart *et al*. 1999 “PIV measurements of a microchannel flow” *Exp. Fluids* **27**, 414-419

Additional Information	N/A
Application Instructions	Please submit CV, unofficial transcript, to Prof. Axel Guenther, e-mail: axel.guenther@utoronto.ca