MIE505 – WINTER 2025
MICRO/NANO ROBOTICS

Department of Mechanical and Industrial Engineering – University of Toronto

Course Overview

Micro- and nano- robotics is an interdisciplinary field which draws on aspects of microfabrication, robotics, medicine and materials science. This project-focused course will cover the design, modeling, fabrication, and control of miniature robot and micro/nano-manipulation systems for graduate and upper-level undergraduate students.

In addition to basic background material, the course includes case studies of current micro/nano-systems, challenges and future trends, and potential applications. The course will focus on a team design project involving novel theoretical and/or experimental concepts for micro/nano-robotic systems with a team of students. Depending on the nature of the topic chosen, these projects can also involve hands-on experience and experimental demonstrations.

Instructors

Instructor	**Eric Diller**	**E-mail**	**ediller@mie.utoronto.ca**
Office Hours	**Thursdays 1pm (after lecture)**		
Practical TA	**Anastasia Aubeeluck**	**E-mail**	**anastasia.aubeeluck@mail.utoronto.ca**

Lecture, Tutorial, and Lab Schedule

Lecture	**Mondays**	**10-12 pm**	**BA xx**
	Tuesdays	**9-10 am**	**BA xx**
Practical	**Wednesdays**	**9am-12pm**	**MY570**

Marking Scheme

Problem Sets	15%
Lab Reports	10%
Group Project	
Proposal	*5%*
Final Report	*20%*
Final Presentation	*15%*
Final Exam	35%
Total	100%

*Late submissions of lab reports and design project deadlines will be subject to a 10 percentage point penalty for each day late. Late submissions to problem sets cannot be accepted, as solutions may be posted immediately after the deadline.

Course Text

There is not a required textbook for the course. Supplementary materials to the course notes will be provided on each topic, taken from the review, tutorial and recent journal article literature. Additional suggested textbooks will be listed for depth on some topics. Students will be responsible for material covered in lectures.

Practicals (Labs)

Several Practicals will be held throughout the term in the Robotics Institute labs on Myhal 5th floor. Students will be assigned to specific dates which will be spread through the term, so each student will only attend several of these sessions. Lab details and schedules will be posted to Quercus throughout the term, but it is expected that students be free during the scheduled Practicals hours.

Topics will include microfabrication, image processing, and visual servoing of micro-robotic devices. Each student will complete a lab report for each session.

MIE department Lab Safety Training must be completed prior to your first Practical, with no exceptions. Comprehension of the safety training will be evaluated during the Practical.

The TA Masoud is the contact person for any Practical matters (masoud.moghani@mail.utoronto.ca).

Group Project

Deadline	**Due Date** (1pm)
Team formation	September 25
Proposal and Literature Review	October 16
Report Draft (outline)	November 20
Final Report	December 4
Final Presentations	Last 2 weeks

Students will form teams of 3-5 students in a design and analysis-based semester project. The projects should incorporate elements of novel micro/nano actuation, sensing or control using computer vision and visual servoing. Successful projects will include rigorous physics-based modelling, computer-aided design and simulation as the core components. As appropriate, groups will also be encouraged to create physical prototypes or experimentally validate their concepts through proof-of-concept demonstrations. Microrobotics Lab facilities will be available for fabrication and experimentation under supervision.

Detailed project requirements and evaluation criteria will follow in a separate document.

Tentative Lecture Topics and Schedule

As an additional resource for you, lectures will be recorded through the Opencast OCCS recording system. Note that this is not intended to capture every element of the class, but will record sound spoken by Prof. Diller, and the screen. To access the lectures in a rich way, please attend in person.

Weeks 1-2	Introduction to micro/nano robotics, microfabrication
Week 3	Swimming microrobots; Scaling laws
Weeks 4-5	Micro-scale actuation: electrostatic, magnetic
Week 6-8	Computer vision: cameras and optics, filtering, edge detection and feature matching Visual servo control: proportional controllers, stability, noise, model-based control, motion planning
Week 9	Powering microrobots and piezoelectric actuation
Week 10	Microrobot sensors
Week 11	Biologically inspired microrobots: Artificial bacterial flagella and molecular motors
Week 12	Final presentations

Learning Objectives

Upon successful completion of this course, you should be able to:

- Understand the relevant physics and methods of current micro-robotics techniques
- Generate physics-based mathematical models of micro-scale mechanical systems
- Access and critically analyze the current literature in robotics/microsystems topics
- Design and use feedback control systems based on visual or other sensory information
- Gather experimental data from physical experiments and interpret it to make critical conclusions
- Communicate complex technical ideas to a broad audience through written and oral techniques
- Identify and add to the state of the art in the field through novel research

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Plagiarism and Conduct

All students are expected to behave as professional engineers, and follow the rules of conduct outlined in your student handbook. All work will be carefully checked for plagiarism, and tests will be carefully monitored by the instructor. Cheating and plagiarism are serious academic offenses, and will be dealt with according to university policy. For the problem sets and lab reports in particular, you are **required to complete the work on your own** – you will be responsible for solving similar problems on the exams.