



## Course Outline

### Instructor

- Vahab Khoshdel, P.Eng.  
E1-588 EITC  
(204) 474-6362  
Vahab.Khoshdel@umanitoba.ca

### Office Hours

- By appointment

### Teaching Assistant

- Amir Attar  
attara1@myumanitoba.ca

### Contact Hours

- 4 credit hours
- Lectures:  
3 hours x 13 weeks = 39 hours
- Laboratories:  
3 hours x 5 weeks = 15 hours

### Prerequisites:

- ECE 4150 Control Systems
- ECE 4240 Microprocessor Interfacing

## Traditional Territories Acknowledgement

*The University of Manitoba campuses and the Department of Electrical and Computer Engineering are located on original lands of the Anishinaabeg, Cree, Ojibwe-Cree, Dakota, and Dene peoples, and on the homeland of the Red River Métis.*

*We respect the Treaties that were made on these territories, we acknowledge the harms and mistakes of the past, and we dedicate ourselves to move forward in partnership with Indigenous communities in a spirit of Reconciliation and collaboration.*

## ECE 4180 – Introduction to Robotics

Winter 2024

### Course Objectives

This course provides fundamental concepts of robotics, including robot classification and applications, mathematics of robot modeling and kinematics, mathematics of small-scale (differential) motion, sensor and actuators, sensor interfacing, motor control, trajectory planning, path planning and robot programming. Robotics is an interdisciplinary subject involving aspects of mathematics, electrical, computer, and mechanical engineering, and applies mathematical techniques and algorithms to overcome automation problems. Both the theoretical aspect of robotics and real applications will be discussed and presented, including 6-degrees of freedom robot wrists, robot control and stability.

### Course Content

The following topics will be covered:

#### Module I: Forward and Inverse Kinematics

- Forward kinematics for 3DoF manipulators
- Linear algebra review
- Rotation matrices
- Homogeneous transformations
- Denavit-Hartenburg notation
- Inverse kinematics for position and orientation
- Kinematic decoupling

#### Module II: Differential Motion

- Robot Jacobian and velocity kinematics
- Trajectory execution robot singularities and Jacobian
- Decoupling singularities
- Redundancy and Jacobian

#### Module III: Computer Vision

- Linear filtering
- Template detection
- Edge detection
- Interest point and keypoint detection

#### Module IV: Robot Control

- Torque, speed, moment of inertia
- Position control, proportional control
- Review of control systems
- First order systems
- Second order systems
- Pole placement
- Root locus
- Robot control examples

### Textbook

*Introduction to Robotics: Analysis, Control, Applications*, S.B. Niku, 2nd edition, 2010. (ISBN: 978-0-470-60446-5)

### Other Resources

*Robot Analysis and Control*, H. Asada and J. J. Slotine. New York, NY: Wiley, 1986. ISBN-10: 0471830291, ISBN-13: 978-0471830290

*Introduction to Robotics: Mechanics and Control*, John J. Craig, Addison-Wesley Publishing Company, 3rd Edition, 2003. ISBN-10: 0201543613, ISBN-13: 978-0201543612

*Robot Modeling and Control*, M. Spong, M. Vidyasagar, S. Hutchinson, Wiley & Sons, 2005 ISBN-10: 0471649902, ISBN-13: 978-0471649908

## Important Dates

- **Term Test**  
Wednesday, February 28<sup>th</sup>, 2024  
6:00PM–8:00PM
- **Voluntary Withdrawal Deadline**  
March 20<sup>th</sup>, 2024
- **Louis Riel Day**  
February 19<sup>th</sup>, 2024  
No classes or examinations
- **Spring Break**  
February 20<sup>th</sup> – 23<sup>rd</sup>, 2024  
No classes or examinations
- **Good Friday**  
March 29<sup>th</sup>, 2024  
No classes or examinations

## Accreditation Details

### Accreditation Units

- Mathematics: 25%
- Natural Science: 25%
- Complementary Studies: 0%
- Engineering Science: 25%
- Engineering Design: 25%

### Graduate Attributes

KB: A knowledge base for engineering  
 PA: Problem analysis  
 IN: Investigation  
 DE: Design  
 ET: Use of engineering tools  
 IT: Individual and team work  
 CS: Communication skills  
 PR: Professionalism  
 IE: Impact of engineering on society/  
 environment  
 EE: Ethics and equity  
 EP: Economics and project  
 management  
 LL: Life-long learning

### Competency Levels

I - Introduced (Introductory)  
 D - Developed (Intermediate)  
 A - Applied (Advanced)

## Learning Outcomes

1. Understand the mechanical aspects of robots.
2. Become familiar with the principle of sensors and actuators and their usages in robotics.
3. Understanding of the mathematics of forward and inverse kinematics of robots.
4. Understand the mathematics of robot Jacobian, differential motion and redundancies.
5. Proposing, implementing, and documenting a robot design project.
6. Learning about computer vision.

## Expected Competency Levels

Outcome	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	D	I			D		I					I
2	D	D	D		D		I					I
3	A	A	A	A	A		I					I
4	A	A	A	A	A		I					I
5	A	A	D		A		I					I
6	D	D					D					I

## CEAB Graduate Attributes Assessed

KB.3 – Recalls and defines, and/or comprehends and applies information, first principles, and concept in specialized engineering science.

PA.3 – Analyzes and solves complex engineering problems.

## Evaluation

The final course grade will be determined from a student's performance in laboratories, assignments, and on examinations. Programmable calculators are not allowed in the mid-term and final examination. Students must receive a minimum of 50% on the final examination and must complete all the laboratories in order to be eligible to receive a passing grade.

Component	Value (%)	Method of Feedback	Learning Outcomes Evaluated
Assignments	10	F, S	1, 2, 3, 4, 5
Laboratories	10	F, S	1, 2, 3, 4, 5, 6
Project	10	F	1, 2, 3, 4, 5, 6
Term Test	25	F, S	1, 2, 3
Final Examination	45	S	1, 2, 3, 4

\* Method of Feedback: F - Formative (written comments and/or oral discussion), S - summative (numerical grade)

## Student Absences

Attendance in lectures, tutorials, and laboratories is mandatory. For short-term absences due to illness or other extenuating circumstances of 120 hours (5 days) or less, students are required to complete a *Self-Declaration Form for Brief or Temporary Absence* available on the University website. This form must be submitted to the course instructor within 48 hours of the absence. (No additional documentation is required.)

Note that students are responsible to complete any missed work and must consult with the instructor to make appropriate arrangements.

For absences longer than 120 hours, students must contact the instructor and ECE Undergraduate Advisor, Tammy Holowachuk (Tammy.Holowachuk@umanitoba.ca) for further instructions.

## Grading Scale

Letter	Mark
A+	95–100
A	85–94
B+	80–84
B	70–79
C+	65–69
C	55–64
D	45–54
F	< 45

Note: These boundaries represent a guide for the instructor and class alike. Provided that no individual student is disadvantaged, the instructor may vary any of these boundaries to ensure consistency of grading from year-to-year.

## Deferred Final Examinations

Students who miss the regular scheduled writing of a final examination, for valid medical or compassionate reasons, may be given the opportunity to write a deferred examination, subject to approval by the Associate Dean (Undergraduate). All requests for a deferred examination must be made within 48 hours of the missed examination, and must follow the procedure described on the Faculty website, without exception. Course instructors do not have the discretion to grant deferred final examinations.

(<https://umanitoba.ca/engineering/student-experience#engineering-student-policies>)

## Academic Integrity

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the *General Academic Regulations on Academic Integrity*, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalty.

## Copyright Notice

All materials provided in this course are copyright and are provided under the fair dealing provision of the Canadian Copyright Act. This material may not be redistributed in any manner without the express written permission of the relevant copyright holder.

## Requirements/Regulations

- Attendance at lectures and laboratories is essential for successful completion of this course. Students must satisfy each evaluation component in the course to receive a final grade.
- It is the responsibility of each student to contact the instructor in a timely manner if he or she is uncertain about his or her standing in the course and about his or her potential for receiving a failing grade. Students should also familiarize themselves with the University's *General Academic Regulations*, as well as Section 3 of the Faculty of Engineering *Academic Regulations* dealing with incomplete term work, deferred examinations, attendance and withdrawal.
- No programmable devices or systems (such as calculators, PDAs, iPods, iPads, cell phones, smart watches, wireless communication or data storage devices) are allowed in examinations unless approved by the course instructor.
- Students should be aware that they have access to an extensive range of resources and support organizations. These include Academic Resources, Counselling, Advocacy and Accessibility Offices as well as documentation of key University policies e.g. Academic Integrity, Respectful Behaviour, Examinations and related matters.

 [Supplemental Resources](#)

## Retention of Student Work

Students are advised that copies of their work submitted in completing course requirements (i.e. assignments, laboratory reports, project reports, test papers, examination papers, etc.) may be retained by the instructor and/or the department for the purpose of student assessment and grading, and to support the ongoing accreditation of each Engineering program. This material shall be handled in accordance with the University's *Intellectual Property Policy* and the protection of privacy provisions of *The Freedom of Information and Protection of Privacy Act (Manitoba)*. Students who do not wish to have their work retained must inform the Head of Department, in writing, at their earliest opportunity.