Course Outline

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

Office Hours
- By appointment

Teaching Assistant
- Shirin Chehelgami
  chehelgs@myumanitoba.ca

Contact Hours
- 4 credit hours
- Lectures: 3 hours per week
- Laboratories: 3 hours x 5 weeks

Prerequisites:
- ECE 4150 Control Systems
- ECE 4240 Microprocessor Interfacing

Traditional Territories Acknowledgement

The University of Manitoba campuses and research spaces are located on original lands of Anishinaabeg, Ininiwak, Anisininewuk, Dakota Oyate, Dene and Inuit, and on the National Homeland of the Red River Métis.

UM recognizes that the Treaties signed on these lands are a lifelong, enduring relationship, and we are dedicated to upholding their spirit and intent. We acknowledge the harms and mistakes of the past and the present. With this understanding, we commit to supporting Indigenous excellence through active Reconciliation, meaningful change, and the creation of an environment where everyone can thrive. Our collaboration with Indigenous communities is grounded in respect and reciprocity and this guides how we move forward as an institution.

ECE 4180 – Introduction to Robotics

Winter 2026

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 sSingularities
- 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**
  February 24th, 2026
  6:00PM–8:00PM
- **Voluntary Withdrawal Deadline**
  March 19th, 2026
- **Louis Riel Day**
  February 16th, 2026
  No classes or examinations
- **Spring Break**
  February 17th – 20th, 2026
  No classes or examinations
- **Good Friday**
  April 3rd, 2026
  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). This includes the unauthorized use of AI when preparing course deliverables. A student found guilty of contributing to cheating by another student is also subject to serious academic penalty. Integrity also applies to respecting copyrighted course content, which should not be distributed without the creator's permission. Uploading content for the purpose of transcription or other AI-enabled features is commonly a violation of the copyright holder's rights.

Copyright Notice

Requirements and 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 passing final grade.
- It is the responsibility of each student to contact the instructor in a timely manner if they are uncertain about their standing in the course and about their potential for receiving a failing grade. Students should also familiarize themselves with the University's *General Academic Regulations* 🔗, as well as the Price Faculty of Engineering *Academic Regulations* 🔗 dealing with incomplete term work, deferred examinations, attendance and withdrawal.
- No programmable devices or systems (such as calculators, PDAs, smart 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.