University of Manitoba | Price Faculty of Engineering
Department of Electrical and Computer Engineering

Course Outline

Instructor

- Prof. Ahmed Ashraf
  E3-504B EITC
  (204) 474–8179
  Ahmed.Ashraf@umanitoba.ca

Office Hours

- By appointment

Teaching Assistant

- Mahboobeh Norouzi
  norouzi1@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

Course Website:

http://umanitoba.ca/umlearn

Important Dates

- **Term Test**
  Friday, March 5th, 2021
  6:00PM – 8:00PM
- **Voluntary Withdrawal Deadline**
  March 31st, 2021
- **Louis Riel Day**
  February 15th, 2021
  No classes or examinations
- **Spring Break**
  February 16th – 19th, 2021
  No classes or examinations
- **Good Friday**
  April 2nd, 2021
  No classes or examinations

ECE 4180 – Introduction to Robotics

Winter 2021

IMPORTANT NOTICE – Mandatory Requirement to Report

This course will be conducted using remote instruction. Students who are accessing the course from outside of Canada or the USA ***must notify the instructor*** and indicate in which country they are located. Access to software may be restricted from some countries and failure to comply with these restrictions may result in criminal prosecution.

Course Objectives

This course provides fundamental concepts of robotics, including robot classification and applications, robot kinematics, sensor and actuators, sensor interfacing, motor control, trajectory planning, basics of modeling, path planning and robot programming.

Robotics is an interdisciplinary subject involving aspects of 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 Robocup Rescue, Soccer and Humanoid robots leagues.

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)

Accreditation Details

Accreditation Units

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

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

1 - Knowledge (Able to recall information)
2 - Comprehension (Ability rephrase information)
3 - Application (Ability to apply knowledge in a new situation)
4 - Analysis (Able to break problem into its components and establish relationships.)
5 - Synthesis (Able to combine separate elements into a whole)
6 - Evaluation (Able to judge the worth of something)

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.

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

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 kinematics of robots
4. Designing a simple rescue robot and testing it
5. Learning about tele-robotics and virtual reality
6. Learning about computer vision and machine learning.

Expected Competency Levels

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

CEAB Graduate Attributes Assessed

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

PA.2 – Develops and/or implements a strategy to analyze 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	20	S	1, 2, 3
Final Examination	50	S	1, 2, 3, 4

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

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 Information

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.