Western Engineering

Western University
Faculty of Engineering
Mechatronic Systems Engineering Program

MSE 4401 A—ROBOTIC MANIPULATORS

Course Outline Fall/Winter 2025–26

COURSE DESCRIPTION: This course presents an overview of robotic manipulators and the theory behind modelling, planning and control of serial manipulators. It includes topics in robot kinematics and dynamics, differential kinematics, path and trajectory planning, dynamics and control. The material will be presented in a combination of in class lectures, online videos, and in class assignments, which will be reinforced through projects and laboratory work.

ACADEMIC CALENDAR:

https://www.westerncalendar.uwo.ca/Courses.cfm?CourseAcadCalendarID=MAIN_023640_1&SelectedCalendar=Live&ArchiveID=

Introduces the basic principles and techniques involved in modeling, simulating and controlling rigid-link manipulators. Forward and inverse kinematics. Manipulator dynamics. Control of robot manipulators.

PREREQUISITES: MSE 3302A/B.

PRE OR COREQUISITES: MSE 3381A/B or MME 3381A/B.

Restricted to students enrolled in the Mechatronic Systems Engineering program. Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course, and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

CEAB ACADEMIC UNITS: Engineering Science 85%, Engineering Design 15%.

INSTRUCTOR INFORMATION:

CONTACT HOURS:

Lectures occur weekly. Laboratory sessions occur weekly.

LECTURE:	3 hours/week
LAB:	3hrs /9 times during the term

RECOMMENDED/REQUIRED TEXTBOOK: M.W. Spong, S. Hutchinson and M. Vidyasagar, Robot Modeling and Control, Second Edition, New York: John Wiley and Sons, 2020. *Hardcopy version will be allowed during the final exam.*

The textbook costs $159.95 plus applicable taxes. Students are welcome to purchase second-hand or earlier editions of this textbook. Students should not purchase the eBook, as it will not be allowed during the final exam.

RECOMMENDED/ REQUIRED SOFTWARE: MATLAB and Simulink, including the Robotics Toolbox.

RECOMMENDED RESOURCES/REFERENCES: If applicable, other recommended readings will be made available through Brightspace.

GENERAL LEARNING OBJECTIVES (CEAB GRADUATE ATTRIBUTES)

Knowledge Base	A	Engineering Tools	A	Impact on Society	
Problem Analysis	A	Individual & Teamwork	A	Ethics and Equity	
Investigation		Communication	D	Economics and Project Mgmt.	
Design	A	Professionalism		Life-Long Learning	

Notation: x represents the content level code as defined by the CEAB. blank = not applicable; I = introduced (introductory); D = developed (intermediate) and A = applied (advanced).

Rating: I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e. g. no review).

COURSE MATERIALS: Weekly content and guides for the laboratories will be available on the course OWL site. The material for this course will be taught in both lectures and labs; therefore, it is imperative that you attend each lecture and lab.

UNITS: SI

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES:

The following table summarizes the course learning outcomes along with CEAB GAIs where the GAIs in bold indicate ones to be measured and reported annually.

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES	(CAEB) Graduate Attribute
1. Introduction to Robotics and Rigid Motions At the end of this section, students will be able to: a. Define and describe robotic manipulators as well as the different types and their characteristics. b. Define the relative position and orientation of serial links using homogeneous transformation matrices c. Demonstrate ability to define an engineering problem at an advanced level to be solved using serial link manipulators.	KB1, KB3, **PA1**, **D1**, **D2**, ET1, CS3

2. Forward and Inverse Kinematics At the end of this section, students will be able to: a. Compute the forward kinematics of serial manipulators. b. Compute the inverse kinematics of serial manipulators using the algebraic and geometric approaches. c. Demonstrate ability to formulate a strategy to solve an engineering problem and reach substantiated conclusions at an advanced level using robot kinematics	KB1, KB3, **PA2**, **PA3,** ET2, CS3
3. Velocity Kinematics – The Jacobian At the end of this section, students will be able to: a. Calculate the Jacobian Matrix of serial manipulators using various approaches. b. Identify the location of kinematic singularities. c. Use the Jacobian matrix, to calculate velocities, and forces/torques, and to characterize manipulability. d. Demonstrate ability to formulate a strategy to solve an engineering problem and reach substantiated conclusions at an advanced level using robot kinematics.	KB1, KB3, **PA2**, **PA3,** ET2, CS3
4. Path and Trajectory Planning At the end of this section, students will be able to: a. Apply different methods for creating a smooth path in joint space. b. Implement algorithms to achieve adequate robot navigation in the presence of obstacles. c. Demonstrate ability to define and engineering problem, formulate a strategy to implement path planning optimization algorithms, and reach substantiated conclusions at an advanced level.	KB1, KB3, KB4, **PA1**, **PA2**, **PA3**, **D3**, ET2, ET3, CS3

5. Dynamics and Control At the end of this section, students will be able to: a. Formulate the equations of motion of serial manipulators. b. Implement different types of control systems and identify the best way to control a robot. c. Demonstrate ability to formulate a strategy to solve a robotics control problem and reach substantiated conclusions at an advanced level.	KB1, KB3, KB4, **PA2**, ET2, CS3

EVALUATION:

Name	**% Worth**	**Assigned**	**Due Date**	**CEAB GAs ASSESSED**
Project (Total = 3 Steps)	20%			D1, D2, D3 D2, D3 PA1, PA2, PA3, D3
Laboratory (Total = 9 lab sessions combined into 3 reports)	21%			PA1, PA2, PA3 PA1, PA2, PA3 PA1, PA2, PA3
In-class assignments (Total = 7)	24%			
Final Examination	35%	Regular examination period		

Note that the dates listed above are **tentative** and may be adjusted if needed. Marks will be assigned on the basis of method of analysis and presentation, correctness of solution, clarity and neatness.

COURSE POLICIES:

Adhere to the week-to-week requirements as outlined each week. Paying close attention to the videos and attempting the examples before looking at the answers will ensure your understanding of the topics and will allow you to gain the most from the course.

While every student works at a different level, it is the effort placed in each requirement that ultimately leads to success. Your interest in the course, participation in the course by asking relevant questions, and communicating with the instructor, will all contribute to your successful completion of the assignments, labs and examinations, and are all highly encouraged.

It is your responsibility to determine what is required of you. Read through the online materials to determine the instructions regarding assignments, laboratory sessions or exams.

Project:

The project will be completed in 3 steps. Step 1 is worth 5% of the final grade. Step 2 is worth 5% of the final grade. Step 3 is worth 10% of the final grade. Reports are to be handed in online.

Project reports are expected to be completed individually. Plagiarism checks will be in place to ensure that each student submits original material. A minimum mark of 50% in the total project grade is required to pass the course.

Project reports will be penalized by 10% of the available marks per weekday for late submission. For deadlines that fall on a Friday at midnight, the penalty will apply at 12:01 am on Monday morning. Project reports submitted more than 2 weeks late will not be accepted.

Laboratory:

All students will attend a 3-hour laboratory session each week. Three laboratory reports will be completed throughout the term, each one corresponding to three weeks of lab work, and worth 7% of the final grade. Lab reports are to be handed in online and are due 1 week after the third laboratory session for each lab, or on the last day of class, whichever is earlier.

Attendance at all laboratory sessions is mandatory. Self-reported absences from laboratory sessions is not allowed. Absence from any session, or a portion of a session, without permission will result in a zero assigned to the corresponding laboratory report. Students who arrive 20 min after the scheduled lab time without a legitimate reason, leave the lab early without permission from the TA, or miss the lab without a legitimate reason will receive a zero for the corresponding laboratory report. Students who miss a lab with academic consideration are required to contact the course instructor within 72 hours for further instructions. Failure to do so will result in a zero mark for that lab. A minimum mark of 50% across all laboratory exercises is required to pass the course.

Laboratory reports will be penalized by 10% of the available marks per weekday for late submission. Deliverables submitted more than 1 week late will not be accepted.

In class assignments:

A total of 7 in-class assignments will take place in person on the dates indicated above (all take place on Mondays between 3:30 and 5:20 pm). Each assignment will be handed in at the end of class, and will count for 4% of the final grade. The grade for the 6 highest marks will be considered towards the final grade. Each student is expected to submit the assignment, but collaboration during class is allowed.

If a student does not attend class on one of the assignment dates, they will not be allowed to complete the assignment on a different day or in an alternative format, regardless of the circumstances for which class was missed.

A grade of zero will be assigned for each missed assignment. If students miss 1/7 in-class assignments, the remaining 6 assignments will be used in the calculation of the final grade. If students miss 2 or more in-class assignments without academic consideration, the average of the highest 6 assignments will be used in the calculation (including the zeros for the missed assignments).

In order to receive academic consideration, advise the instructor if you are unable to attend an in-class assignment prior to the due date. Submit an Academic Consideration Request and provide documentation if requested by the instructor at:
https://www.eng.uwo.ca/undergraduate/academic-consideration-for-absences.html
If you are granted an extension, the instructor will reweight the assignment, where reweighting means that the marks normally allotted for the assignment will be added to the final exam.

Final Examination: The final examination will take place in-person during the regular examination period. The exam will cover all of the material covered in class and in the labs. In this exam, you will be allowed to bring a hardcopy of the approved textbook, and/or a formula sheet (two-sided formula sheet with no drawings or examples to be approved by the instructor). Standard calculators will be allowed. A total of 3 hours will be allotted for the completion of the exam.

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination. A final examination mark < 50% will result in a final course grade of 48% or less.

If the above conditions are not met, your final grade cannot be greater than 48%. Students who have failed this course (i.e., final average < 50%) must repeat all components of the course.

ATTENDANCE: Attendance is mandatory for all lectures and labs.

FACULTY OF ENGINEERING POLICIES:
Students must familiarize themselves with the policies of the Faculty of Engineering