

Western University
Faculty of Engineering
Department of Electrical and Computer Engineering
Mechatronics Systems Engineering Program

MSE 4401A/B: Robotic Manipulators
Course Outline: Fall Semester, 2015

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 and control. The material will be presented in a combination of lectures and in class exercises, reinforced through assignments and laboratory work.
Instructor:	Ana Luisa Trejos TEB 373, 519-661-2777 ext. 89281 CSTAR, 519-685-8500 ext. 32529 atrejos@uwo.ca Office hours: Upon request @ TEB-373
Academic Calendar Copy:	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. Prerequisite(s): MME 2213A/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.
Hours:	Contact Hours: 3 lecture hours, 1.5 laboratory/project hours, 0.5 course. Tuesdays 11:30 to 12:30 – UCC-58 Thursdays 10:30 to 12:30 – EC-2130 Laboratory group 1: Wednesdays 3:30 to 5:00 pm, SEB-3101 Laboratory group 2: Wednesdays 5:00 to 6:30 pm, SEB-3101
CEAB Academic Units:	Engineering Science 100%, Engineering Design 0%
Course Materials:	Required textbook: Siciliano, B., Sciavicco, L., Villani, L., Oriolo, G., Robotics: Modeling, Planning and Control, London: Springer-Verlag, 2009. Other recommended readings will be made available through OWL. Software: Matlab, including the Robotics Toolbox.

General Learning Objectives:

Knowledge Base	3/3	Use of Engineering Tools	3/3	Impact on Society and the Environment	
Problem Analysis	3/3	Individual and Team Work		Ethics and Equity	
Investigation		Communication Skills	3/2	Economics and Project Management	
Design		Professionalism		Life-Long Learning	

Notation: x/y , where x is the cognitive level (1: Remember, 2: Understand, 3: Apply) at which the attribute is assessed and y is the academic level (1: Beginner, 2: Intermediate, 3: Advanced) at which the attribute is assessed.

Topics and Specific Learning Objectives:

1. Introduction to Robotics and Rigid Motions

At the end of this section, students will be able to:

- Distinguish which mechatronic devices can be considered robots.
- Describe the characteristics, types and uses of various robotic manipulators.

2. Forward and Inverse Kinematics

At the end of this section, students will be able to:

- Compute the forward kinematics of serial manipulators.
- Compute the inverse kinematics of serial manipulators using the algebraic, geometric and numerical approaches.

3. Velocity Kinematics – The Jacobian

At the end of this section, students will be able to:

- Calculate the Jacobian Matrix of serial manipulators using various approaches.
- Identify the location of kinematic singularities and characterize manipulability.

4. Path and Trajectory Planning

At the end of this section, students will be able to:

- Describe when it is necessary and possible to identify a collision-free path for a robot.
- Implement algorithms to achieve adequate robot navigation and path planning.

5. Dynamics and Control

At the end of this section, students will be able to:

- Formulate the equations of motion of serial manipulators.
- Implement different types of control systems and identify the best way to control a robot.

Evaluation:

Grades for the course will be determined on the following basis:

Assignments	15 %
Lab reports	15 %
Midterm	20 %
Final exam	50 %

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.

All work submitted must be of professional quality. Material that is handed in dirty, illegible, or disorganized will be returned to the student for resubmission and the late submission penalty will take effect. An additional penalty of 10% may be deducted for poor grammar, incoherence or lack of flow in the written reports.

Homework

Assignments:

There will be a maximum of 6 assignments spread out throughout the term. Due dates are non-negotiable. Assignments are to be handed in during class and are due at the start of the class period on the due date. Late submissions will be penalized 10% per class period (applied as soon as the lesson is over and cumulative on a weekly basis). If applicable, assignment solutions will generally be released within one week of the assignment due date. Any assignments received after solutions have been posted will receive a grade of zero.

All work submitted must be of professional quality. Material that is handed in dirty, illegible, or disorganized will be returned to the student for resubmission and the late submission penalty will take effect.

Laboratory:

All students will attend a 1.5 hour laboratory session each week. Absence from any session without permission will result in a zero assigned to the corresponding laboratory report. Three laboratory reports will be completed throughout the term for the following topics:

Kinematics – 4 lab sessions (6 hours)

Path planning and obstacle avoidance – 2 lab sessions (3 hours)

Dynamics and control – 4 lab sessions (6 hours)

Lab reports are to be handed in during the assigned laboratory period and are due at the start of the period on the due date. Late submissions will be penalized 10% per week day (applied as soon as the period is over and cumulative on a daily basis). As with the homework assignments, all work submitted must be of professional quality. Material that is handed in dirty, illegible, or disorganized will be returned to the student for resubmission and the late submission penalty will take effect.

Midterm Test:

The Midterm Test will be held on Tuesday October 22nd during class – The test will cover the material covered in class up to that point. This exam will be closed-book with a cheat sheet allowed that must be approved by the instructor ahead of time. Standard calculators will be allowed. A total of 1 hour and 40 minutes will be allotted for the completion of the exam.

Final Examination:

The final examination will take place during the regular examination period. The exam will cover all of the material covered in class and in the labs. This exam will be closed-book with a cheat sheet allowed that must be approved by the instructor ahead of time. Standard calculators will be allowed. A total of 3 hours will be allotted for the completion of the exam.

How to succeed in this course:	<p>Class attendance is highly encouraged. Attention to the events happening in each lecture will ensure your understanding of the topics and will allow you to gain the most from the course.</p> <p>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 class by asking relevant questions, and talking to the instructor during office hours will all contribute to your successful completion of the assignments, labs and examinations and are all highly encouraged.</p>
Assignment Submission Locker:	To be determined.
Use of English:	In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.
Attendance:	All classes, laboratories, and tutorials are mandatory unless otherwise stated. Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.
Absence Due to Illness or Other Circumstances:	<p>Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached "Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled"). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.</p> <p>For more information concerning medical accommodations, see the relevant section of the Academic Handbook:</p> <p>http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf</p> <p>For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:</p> <p>http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf</p>
Missed Midterm examinations:	If a student misses a midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their department within 24 hours of the missed test. The department will decide whether to allow the reweighting of the test, where

reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

Cheating and Plagiarism:

Students must write their reports and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Use of Electronic Devices Policy:

Turn off all sound for pagers and cell phones. Students may use laptops, tablet computers, or smart phones *only* to access the course OWL site or for taking in-class notes during lectures, labs and tutorials. Only the use of *nonprogrammable* calculators is permitted during examinations. No other electronic devices may be used at any time during lectures, tutorials, or examinations.

Policy on Repeating All Components of a Course:

Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

Internet and Electronic Mail:

Students are responsible for regularly checking their Western e-mail and the course web site (<https://owl.uwo.ca/portal/>) and making themselves aware of any information that is posted about the course. If the student fails to act on information that has been posted on these sites and does so without a legitimate explanation (i.e., those covered under the illness/compassionate form), then there are NO grounds for an appeal.

Accessibility: Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

Support Services: Office of the Registrar, <http://www.registrar.uwo.ca/>
Student Development Centre, <http://www.sdc.uwo.ca/>
Engineering Undergraduate Services, <http://www.eng.uwo.ca/undergraduate/>
USC Student Support Services, <http://westernusc.ca/services/>

Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain help.

Other course policies: Please make an effort to be in the class room ready to start at the class start time. Lectures will start promptly and immediate attention will be required from the start.