

## Course Outline

### 1. COURSE INFORMATION

<b>Session Offered</b>	Winter 2022	
<b>Course Name</b>	Robot Mechanics & Mechatronics	
<b>Course Code</b>	MANTECH 4RM3	
<b>Date(s) and Time(s) of lectures</b>	Saturday Mornings 9:00 am – 12:00 noon January 10 – April 12, 2022	
<b>Program Name</b>	Manufacturing Engineering Technology	
<b>Calendar Description</b>	Basic robot categories; robot components; mobility/constraint analysis; workspace analysis; manipulator kinematics and motion trajectories; non-redundant and redundant sensing/actuation of manipulators; manipulator statics; singularities; and manipulator dynamics.	
<b>Instructor(s)</b>	Dr. Timber Yuen, P.Eng.	

### 2. COURSE SPECIFICS

<b>Course Description</b>	Theories behind operation and control of various motors, actuators and sensors commonly used in automation and robotics are first introduced. The use of micro controllers to integrate the various sensors and actuators is also discussed. Robot types, categories and workspace analysis methods are examined. Forward kinematics, inverse kinematics, D-H algorithm, trajectory planning and robot force control topics are investigated as well.				
<b>Instruction Type</b>	Code	Type	Hours per term		
	C	Classroom instruction	36		
	L	Laboratory, workshop or fieldwork			
	T	Tutorial			
	DE	Distance education			
<b>Total Hours</b>			36		
<b>Resources</b>	ISBN	Textbook Title & Edition	Author & Publisher		
	ISBN - 978-0133489798	Introduction to Robotics – Mechanics & Control, 4 <sup>th</sup> edition	J.J. Craig, Pearson Prentice Hall, 4th edition 2017		
	Other Supplies	<b>Source</b>			
<b>Prerequisite(s)</b>	N/A				
<b>Corequisite(s)</b>	N/A				
<b>Antirequisite(s)</b>	N/A				
<b>Course Specific Policies</b>	All assignments and lab reports must be handed in before or on the due date. No late submissions will be accepted.				
<b>Departmental Policies</b>	Students must maintain a GPA of 3.5/12 to continue in the program. In order to achieve the required learning objectives, on average, B.Tech. students can expect to do at least 3 hours of “out-of-class” work for every scheduled hour in class. “Out-of-class” work includes reading, research, assignments and preparation for tests and examinations.				

	<p>Where group work is indicated in the course outline, such collaborative work is mandatory.</p> <p>The use of cell phones, iPods, laptops and other personal electronic devices are prohibited from the classroom during the class time, unless the instructor makes an explicit exception.</p> <p>Announcements made in class or placed on Avenue are considered to have been communicated to all students including those individuals that are not in class.</p> <p>Instructor has the right to submit work to software to identify plagiarism.</p>
<b>3. SUB TOPIC(S)</b>	
Week 1	<p>Introduction to Robotics</p> <ul style="list-style-type: none"> <li>• Robot categories</li> <li>• Workspace Analysis</li> <li>• Forward &amp; Inverse Kinematics (2 Link Robots)</li> </ul>
Week 2	<p>Motors &amp; Actuators for Robotics &amp; Automation</p> <ul style="list-style-type: none"> <li>• Motors: DC, DC Brushless, AC, Stepper &amp; Servo</li> <li>• PWM for DC Motor Speed Control</li> </ul> <p>Sensors for Automation</p> <ul style="list-style-type: none"> <li>• Potentiometer for position feedback</li> <li>• Encoders</li> </ul> <p>Demo: Printer Homing with Stepper Motors</p>
Week 3	<p>Introduction to Micro Controller</p> <ul style="list-style-type: none"> <li>• I/O Definition</li> <li>• Variables</li> <li>• Programming a Micro Controller</li> <li>• Sample Programs</li> <li>• Truth Table Logics (for H Bridge Logics)</li> </ul>
Week 4	<p>Modified Micro-Controller Lab/Demo (1 Hour - online)</p> <ul style="list-style-type: none"> <li>• Finish left over material from Week 3</li> <li>• Review for Test #1</li> </ul>
Week 5	Mid Term Test #1
	Study Break
Week 6	<p>Advanced Kinematics</p> <ul style="list-style-type: none"> <li>• Mobile Frames &amp; Fixed Frames</li> <li>• Joint Space, World Space &amp; Tool Space</li> <li>• Coordinate Frames, Translations &amp; Rotations</li> <li>• Homogeneous Transformation</li> </ul>
Week 7	<p>D-H Algorithm Week 1</p> <ul style="list-style-type: none"> <li>• Robot Frames for Tracking Robot Movement</li> </ul>
Week 8	<p>D-H Algorithm Week 2</p> <ul style="list-style-type: none"> <li>• Review for Test #2</li> </ul>
Week 9	Mid Term Test #2
Week 10	<p>Velocities &amp; Jacobian</p> <ul style="list-style-type: none"> <li>• Joint Space vs Cartesian Space Trajectories</li> <li>• Multiple-Joint Coordinated Motion</li> <li>• Velocity Analysis &amp; Jacobian Matrix</li> </ul>

	<ul style="list-style-type: none"> <li>• Force Control and Singularities</li> </ul>	
Week 11	<ul style="list-style-type: none"> <li>Trajectory Generation</li> <li>• Popular PEO Questions on Trajectory Generation</li> <li>• And a few other examples</li> </ul>	
Week 12	<ul style="list-style-type: none"> <li>Final Review</li> <li>Take up Problem Set #3</li> </ul>	

Midterm Recess: Monday, February 21 to Sunday, February 27

Classes end: Wednesday, April 12

Final Examination Period: April 14 to April 29

All examinations **MUST** be written during the scheduled examination period.

Note that this structure represents a plan and is subject to adjustment term by term.

The instructor and the University reserve the right to modify elements of the course during the term. The University may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes.

<b>4. ASSESSMENT OF LEARNING</b>	<b>Weight</b>
3 Assignments (3 x 5% each)	15%
Mid Term Test #1	25%
Mid Term Test #2	25%
Final Exam	35%
<b>TOTAL</b>	<b>100%</b>

Percentage grades will be converted to letter grades and grade points per the University calendar.

## **5. LEARNING OUTCOMES**

1. Understand the pros and cons of various sensors and motors for the design of a robotics system.
2. Programming of a micro controller to integrate inputs (sensors and push buttons) and outputs (lights and motors)
3. Recommend the type of robot used in a manufacturing cell based on the requirements on accuracy, work envelope and the manufacturing process.
4. Robot trajectory planning and force control based on motion specifications.
5. Forward kinematics and inverse kinematics
6. Prepare students for writing the PEO Robotics Exam

## **6. COURSE OUTLINE – APPROVED ADVISORY STATEMENTS**

### **ANTI-DISCRIMINATION**

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

[http://www.mcmaster.ca/policy/General/HR/Discrimination\\_Harassment\\_Sexual\\_Harassment-Prevention&Response.pdf](http://www.mcmaster.ca/policy/General/HR/Discrimination_Harassment_Sexual_Harassment-Prevention&Response.pdf)

### **ACADEMIC INTEGRITY**

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of

credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty: The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

### **AUTHENTICITY / PLAGIARISM DETECTION**

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to [www.mcmaster.ca/academicintegrity](http://www.mcmaster.ca/academicintegrity).

### **COURSES WITH AN ON-LINE ELEMENT**

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

### **ONLINE PROCTORING**

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

### **COMMUNICATIONS**

It is the student's responsibility to:

- Maintain current contact information with the University, including address, phone numbers, and emergency contact information.
- Use the University provided e-mail address or maintain a valid forwarding e-mail address.
- Regularly check the official University communications channels. Official University communications are considered received if sent by postal mail, by fax, or by e-mail to the student's designated primary e-mail account via their @mcmaster.ca alias.
- Accept that forwarded e-mails may be lost and that e-mail is considered received if sent via the student's @mcmaster.ca alias.
- Check the McMaster/Avenue email and course websites on a regular basis during the term.

### **CONDUCT EXPECTATIONS**

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

### **ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES**

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or [sas@mcmaster.ca](mailto:sas@mcmaster.ca) to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

### **REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK**

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar “Requests for Relief for Missed Academic Term Work”.

### **ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)**

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests. <http://www.mcmaster.ca/policy/Students-AcademicStudies/Studentcode.pdf>

### **COPYRIGHT AND RECORDING**

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

### **EXTREME CIRCUMSTANCES**

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.